Inflation Targeting

and

Monetary Policy

An Econometric Analysis of 7 OECD Countries and the Eurozone

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ABSTRACT

This doctoral thesis comprises a study of three aspects of inflation targeting and monetary policy in 7 OECD countries that were the first to introduce inflation targeting as well as the U.S. and the Eurozone who do not pursue an explicit inflation targeting strategy. The first chapter finds that transparency which often has accompanied the inflation targeting strategy of central banks has not helped the private sector to better predict the future policy interest rate. Furthermore, no significant improvement was observed after inflation targeting was introduced. The private sector's forecast of the policy rate is better in the non-inflation targeting countries. By estimating the Taylor using GMM in chapter two, it can be shown that most of the inflation targeting countries do not focus more on controlling inflation than they focus on decreasing the output gap- which is what one would expect to find. The exception is New Zealand who seems to be the only country to run a "hard core" inflation targeting strategy. The estimated coefficients show that most of the inflation targeting countries have been focusing roughly equally on promoting output and controlling inflation and in some cases even more on stimulating output then on controlling inflation. This brings attention to the arguments of two famous monetary policy economists i.e. Svensson and Taylor. Taylor blames the house price bubble in the U.S. on too loose monetary policy. Svensson argues that monetary policy is not to blame but, instead, financial under-regulation is. After investigating both arguments empirically it is possible to conclude that even though loose monetary policy created the foundation of extensive house price increases, it is the lack of regulation in the financial sector that caused the global financial crisis.

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"Character is not cut in marble; it is not something solid and unalterable. It is something living and changing, and may become diseased as our bodies do."

George Eliot

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GLOSSARY

LIST OF ABBREVIATIONS

ABS	Asset Backed Security
Alt-A	Alternative-A Loans
AR	Autoregressive
ARM	Adjustable Rate Mortgage
BP	Basis Point (1/100 of a per cent)
CB	Central Bank
CBOT	Chicago Board of Trade
CDO	Collateralized Debt Obligation
CDO^2	Collateralized Debt Obligation Squared
CDS	Credit Default Swap
CMO	Collateralized Mortgage Obligation
CPI	Consumer Price Index
CUSUM	Cumulative Sum
D-W	Durbin-Watson
ECB	European Central Bank
EMU	European Monetary Union
Fannie Mae	Federal National Mortgage Association
FHA	Federal Housing Administration
FHFA	Federal Housing Finance Agency
FICO	Fair Isaac & Company, credit score
FOMC	Federal Open Market Committee
Freddie Mac	Federal Home Loan Mortgage Corporation
IFS	International Financial Statistics (an IMF database)
i.i.d.	Independent and identically distributed
IMF	International Monetary Fund
IR	Inflation Report

IT	Inflation Targeting
HEL	Home Equity Loans
HICP	Harmonised Index of Consumer Price
HLTV	High Loan to Value
GDP	Gross Domestic Product
Ginnie Mae	Government National Mortgage Association
GMM	Generalized Methods of Moment
GSE	Government Sponsored Enterprise
LTV	Loan to Value
MBS	Mortgage Backed Security
MCI	Monetary Conditions Index
Mor.	Mortgage
MP	Monetary Policy
MPC	Monetary Policy Committee
MSE	Mean Squared Error
Observ.	Observations
OC	Over Collateralization
OECD	Organisation for Economic Co-operation Development
OLS	Ordinary Least Square
SIC	Schwarz Information Criteria
SIFMA	Securities Industry & Financial Market Association
Std. err.	Standard error
VA	Veterans Administration
VAR	Vector Auto Regression
Var.	Variance
VEC	Vector Error Correction

LIST OF SYMBOLS AND ABBREVIATIONS USED IN THE EQUATIONS

i = nominal interest rate

r = target interest rate

π = inflation rate

y = output

α = estimator

β = estimator

ε = error term/ white noise

κ = exogenous variable

η = shock not known yesterday

γ = exogenous event

θ = shock occurring today

δ = discount factor

L = loss function

λ = weight

m = market instrument

r^m = return on market instrument

ff = federal funds market interest rate

ϕ = risk premium

f = rate of interest rate futures

u = residual

τ = coefficient used in the Breusch –Godfrey test

Δ = difference

ρ = smoothing parameter

uh = use of a house

hp = house price

t = real estate tax

φ = depreciation rate

i = mortgage rate

π_h^e = expected rate of appreciation of a house

π^e = inflation rate

di = disposable income

M_n = money supply (n=2,3,4)

cred = private housing credit

cpi = consumer price index

x = vector of stationary and endogenous variables

Π = constant coefficients with full rank

P = coefficient matrix (long-run relationship)

Γ= coefficient matrix (short-run relationship)

1 INTRODUCTION AND PURPOSE OF THE THESIS

One of the first economists to introduce the concept of stable prices was Knut Wicksell (1898). His idea originated from the increasing importance of prices as a measurement of how much a good was worth. He argued that if prices have the function of valuing goods and services, then it must be utterly important that they be kept stable. This should be coordinated by the central bank which has the means to control the interest rate. When the price level is increasing, the interest rate should be raised in order to dampen the increasing prices. And when prices are falling the central bank should lower the interest rate.

Under Chairman Paul Volcker the Federal Reserve started its "war on inflation" in the early 1980s. After years of very high inflation, price stability became the operational objective for monetary policy, in combination with two other stated objectives which were to pursue policies that promote "maximum employment" and moderate long-term interest rates (Orphanides, 2006). With these objectives inflation came down from 14.8 per cent in 1980 to 3.6 per cent three years later (Mankiw 2001). "Low inflation" is considered to be a sign of a healthy economy. Much research has been conducted in order to show how important low inflation is for the economic system. Among others, Feldstein (1999) stresses the importance of low inflation. He finds that even moderate levels of increasing inflation affect economic growth negatively. Mishkin (2007b) also argues that inflation has high costs for the economy and that there is no long-run trade-off between inflation and output. Mankiw (2001) further reasons that low inflation is not the only desired goal, to keep inflation *stable* is also very important.

During the 1990's many countries (e.g. New Zealand, Canada and Sweden[1]) introduced a monetary policy strategy called inflation targeting after being unable to control inflation that in many cases reached double digit levels. Inflation targeting is a framework where the central bank announces its inflation target for future inflation to the public. The target can be a range or an explicit numerical level. It is then the central bank's responsibility to make sure that the inflation level is kept around the target level. (Bernanke et al., 2001)

This doctoral thesis deals with three aspects of inflation targeting and modern monetary policy and is divided into three chapters. Their purposes and contents will be commented individually below.

[1] For a detailed list on inflation targeting countries see appendix 1.

1.1 HAS INFLATION TARGETING LED TO IMPROVED PRIVATE SECTOR INTEREST RATE FORECASTS?

The purpose of the second chapter of this thesis is to explore whether an inflation targeting strategy leads to greater predictability of the future policy rate. An inflation target is a rather simple concept for the public to understand and it gives good indications of what to expect from future monetary policy decisions. Although transparency is not a condition for the implementation of inflation targeting, most inflation targeting countries have increased their monetary policy transparency considerably when they introduced inflation targets (IMF, 2005). According to Berg, Jansson and Vredin (2006) the increased transparency and amount of information have led to enhanced research and interest about what the central bank's role is, and what monetary policy should accomplish.

Benefits from monetary policy transparency have been investigated mainly theoretically[2]. Geraats (2001) concludes that transparency helps the central banks to reduce inflation bias, increase and build a good reputation, and it enables the central banks to achieve greater flexibility when responding to shocks. Inflation bias means that inflation tends to increase over time (Romer, 2001) and it is likely to be reduced as monetary policy becomes more transparent since expectations often are self-fulfilling. According to Ammer and Freeman (1995) the expectations hypothesis developed in the 1970's, is true in the case of inflation i.e. expected low inflation will lead to low realised inflation. This means that if the market anticipates low inflation the inflationary pressure will decline. Hence, the central bank does not have to indulge in drastic interest rate increases that might go beyond the optimal level and cause economic growth to slow down, in order to control inflation. However, for this to work, the central bank, its intended targets and announcements have to be credible. If the central bank repeatedly announces inflation targets that are rarely achieved the central bank loses its credibility and the inflation bias will not be successfully reduced.

The third benefit from increased transparency that Geraats (2001) mentions is greater flexibility. This is based on the reasoning that if the central bank explains planned actions as well as reasons why the previously set target is not attained it can keep its credibility (if the reasons are accepted by the public) even though it was not able to realise the set target. Belke et al. (2005) argue in a similar way and further suggest that the minutes from the European Central Bank (ECB) meetings should be published. They believe that it would enhance the quality of the discussions and better motivate and explain the decisions made by the ECB.

[2] Chortareas, Stasavage and Sterne (2002) have empirically found that increased transparency leads to lower inflation in Inflation targeting countries. Demertzis and Hughes Hallet (2002) come to the contradicting conclusion that transparency does not affect the average inflation level. However, it affects the variability in inflation by as much as 50 per cent.

Inflation targeting countries are not the only countries that have introduced an increasingly transparent monetary policy. The Federal Reserve has increased its transparency since the 1990's even though it does not pursue explicit inflation targeting[3]. In 1994 the Federal Open Market Committee began to announce its policy actions immediately after they were decided. 5 years later press statements were released at the conclusion of every meeting according to Poole, Rasche and Thornton (2002).

Increased transparency makes it easier for the private sector and the financial market to assess the future actions of the central bank. Swanson (2004), Lang, Sack and Whitesell (2003), and Lasaosa (2005) among others, have investigated whether the financial market has improved its foreseeing of future monetary policy developments. Swanson (2004) finds that the private and financial sector do better forecasts of the federal funds rate and interest rates measured by interest rate options at horizons of several months under the new and transparent regime. In order to control whether this is a general improvement of economic forecasting he tests if there have been similar improvements in GDP and inflation forecasting. He does not find similar improvements in GDP and inflation forecasts; hence increased transparency of the Federal Reserve has had a positive effect on the ability of the private and financial market to forecast the federal funds rate. Lange et al. (2003) also conclude that an important shift has occurred during the late 1980's and early 1990's in the ability of financial markets to anticipate monetary policy actions by the Federal Reserve. Through most of the 1980's market prices had predictive power for policy actions only about a month ahead. More recently market yields have become much better predictors of monetary policy moves several months in advance. Similar results have been found by Lange et al. (2003) and Swanson (2005) in the 1990's. There has not occurred a structural break when the Fed increased transparency in 1994, but a gradual improvement in predicting the federal funds rate over the decade can be shown.

Lasaosa (2005) compares the time when the Bank of England was less transparent i.e. before the operational independence in 1997 with the time afterwards. One would expect that if the policy and strategy of the Bank of England becomes more transparent the actions of the bank will be more predictable. Thereby one would assume that the sensitivity of macroeconomic data releases would increase, since the bank has communicated its strategy and the economic actors know how the bank will react based on macroeconomic data. If the Bank of England's official main objective is to keep inflation at a certain level, the market will be focusing on macroeconomic data that reveal the current and expected inflation level. In conflict with his reasoning, Lasaosa (2005) finds that macroeconomic announcements that are relevant in determining future inflation continue to move the market less in the post-independence period and target rate changes by the Bank of England vary to the same

[3] The Federal Reserve focuses on keeping prices stable, but it has not an outspoken numerical target.

extent or more. Furthermore it seems as if the market reactions caused by policy announcements were stronger in the second half than in the first half of the post-independence period. This might be explained by the fact that the Monetary Policy Committee (MPC) and a perceived shift towards a more implicit policy rule may have made the decisions more complicated for the MPC and therefore the decisions are also harder to predict. With time this would however change since one would assume the market will learn how to predict the announcements of the MPC.

Gürkaynak, Sack and Swansson (2007) investigate which financial instrument is the best at capturing expectations and foreseeing future developments of monetary policy. The instruments tested are: federal funds loans, federal funds futures, Eurodollar deposits, Eurodollar futures, Treasury Bills and commercial papers. The results show that the federal funds future has the best forecasting power of the actual federal funds rate at all-time horizons measured (i.e. 1-6 months). Federal funds future is the American name for U.S. interest rate futures and in the reminder of this thesis federal funds future will be referred to as interest rate futures.

The empirical section of the chapter employs Gürkaynak et al. (2007) econometric regression model. The regression is run on the five pioneering inflation targeting countries[4] and on three non-inflation targeting countries[5] which are used as a reference group. The primary aim is to find out whether the private sector has become better at predicting the policy rate after inflation targeting was introduced. Secondly, it investigates whether the predictability of the policy rate has improved over time as the private sector adjusts to the new monetary system and learns more about the behaviour of the central banks and how to interpret their communication which is suggested by Lasaosa (2005).

1.2 Measuring the inflation and non-inflation targeting countries behaviour using the Taylor rule

In the second chapter of this thesis it is shown that the inflation targeting strategy has not (significantly) improved the private sector's ability to predict the future policy rate. This result raises questions as why the private sector has not improved its interest rate forecasts. Is it possible that the central banks have behaved differently than they said they would or have the rules of the game changed?

[4] UK, New Zealand, Canada, Australia and Sweden.

[5] Japan, U.S. and the Eurozone.

The third chapter will estimate what the policy rate had been considering inflation and output if they had only used Taylor's original rule. The Taylor rule is explained in chapter two and applied empirically in this chapter for the purpose of further assessments on how the central banks have behaved given the prevailing economic conditions.

The first part of the empirical analysis uses the Taylor rule to give a graphic presentation of what the interest rate would have been if the central bank would have focused equally on controlling that the inflation level reached the set target and on controlling that output grew at its potential level. Taylor's original equation sets the weights on inflation and output equal to 0.5 and these weights are also used in this study. The target inflation rate is set at the countries individual targets e.g. in Sweden 2 per cent and Australia 2.5 per cent. For the U.S. and the Eurozone who do not have an explicit inflation target the target inflation rate is assumed to be 2 per cent.

If a country's central bank follows an inflation targeting strategy one would expect the weight put on inflation to be larger than the weight put on output (Svensson 1999, see section 2.3). The second part of the empirical analysis estimates whether this is the case in the inflation targeting countries in this study; hence, do the inflation targeting central banks put more weight on controlling inflation than output? The basic concept of the Taylor rule is explained in Taylor (1998). He has found that the weight put on inflation must be larger than one if monetary policy is to be able to control inflation efficiently. Clarida, Gali and Gertler (2000) agree with this and have found that if the weight is smaller than one it will result in uncontrolled inflation. Furthermore, the weight put on the output gap must be larger than zero according to "Taylor's principle" (1998). This implies that if the economy's output is above its potential level the interest rate must be increased to cool off the economy (Woodford, 2001).

The Taylor rule will be econometrically estimated by using General Methods of Moments (GMM). This method is employed since the reaction function is forward looking; hence the central bank policy committees only have access to data describing past inflation, output and interest rate when they set the policy rate that shall control future inflation and output. Central banks use interest rate smoothing which implies that if the members of the policy committee decide to change the policy interest rate they usually change it in a number of small steps over a period of time i.e. the policy rate moves smoothly over time. Therefore most economists estimate the Taylor rule using a smoothing parameter. This is also done in this study, however the smoothing parameter seems to explain almost the entire variation of the policy interest rate. Since the purpose is to find how the variation in the inflation rate and output affects the future policy rate the equation will be estimated once more without the smoothing parameter. By excluding the smoothing parameter the variation of the interest rate is better explained by the variation of the inflation rate and output gap. The result of the

graphic and econometric estimations are analysed and explained by data on the consumer price index (CPI) development between 1950 and 2009 in the different countries.

1.3 THE ROLE OF MONETARY POLICY IN THE CURRENT FINANCIAL CRISIS

The conclusion in chapter three shows that most of the central banks in the countries in this study have set the policy interest rate relatively low compared to the interest rate calculated by using Taylor's rule over the years 2001 and 2006. Belke and Klose (2010) have found a similar result, by using a state-space model and GMM to estimate the Taylor rule for the Eurozone and the U.S. Both ECB and the Federal Reserve Bank have violated the Taylor principle during the years 1999 to 2007 i.e. the estimated coefficient for inflation has been lower than one. In other words, the central banks have run a monetary policy that was almost exclusively focusing on pushing output through these years, which suggests that both banks ran a loose monetary policy. The purpose of this chapter is to decide what role the loose monetary policy has played in the current financial crises. Two famous economists have disagreeing opinions about this and the first part of chapter four analyses their arguments.

The economist, Taylor (2007 and 2009) argues that the loose monetary policy in the U.S. was the reason for the booming house prices and the bubble that finally burst. He criticises the Federal Reserve Bank's loose monetary policy. It was not able to control the unhealthy house price development. Taylor (2007) performs an exercise where he estimates the relationship between housing starts and the interest rate. He finds that fewer houses would have been built if the interest rate had been set higher.

The economist, Svensson (2010) disagrees with Taylor and calls for additional control of the lending sector in order to control the housing market. His view is that the central bank should be responsible for creating stable prices by using inflation targeting as stable prices is an important prerequisite for economic growth. At times of slow economic growth the central bank can temporarily let inflation deviate from the target in order to push output growth. This is called flexible inflation targeting. Hence the priorities of the central bank should primarily be to control that the inflation level reaches its inflation target and secondly to monitor that the output gap is closed. Regulating house prices is not a task for the central bank according to Svensson. According to Svensson the central bank should focus on keeping prices stable. The Federal Reserve Bank does not pursue inflation targeting as an outspoken strategy, however it does attempt to keep inflation low. And looking at the inflation level

(measured by the change in CPI) there is no reason to argue that inflation was alarmingly high. In 2006, CPI grew by 3.2 per cent, 2007 2.9, and reached 3.8 per cent in 2008[6].

Could the house price bubble been avoided if central banks had raised interest rate? Was monetary policy too loose?

In order to answer this question, the fourth chapter will empirically test what effect the policy interest rates have on house prices. This will be done by utilizing vector error correction models for each country individually. The countries include the UK, New Zealand, Canada, Australia, Sweden and the U.S. Most empirical research that estimates the relationship between house prices and the interest rate has been conducted by using the short term interest rate. This study will, nevertheless, use the policy interest rate. The impulse response analysis show that house prices respond negatively to increasing interest rates in the long run; hence house prices would probably been lower under a higher interest rate. However, this does not seem to answer why the financial crisis became as widespread as it was and led to the worst financial crisis since before World War II. Mishkin (1997) argues that until now housing and mortgage market has not caused major financial instability. Although, when deregulation, liberalisation and financial innovation occur at the same time, it often leads to lending booms. And in 2007 Mishkin warned that (2007a) the quick growth of the U.S. subprime market was reason for concern. When house prices increased quickly investors were becoming more and more willing to take on extra risk and thereby financed new mortgages to borrowers in this market. But who would have thought that the subprime market which only made out 6 per cent of the U.S. traditional banking system could cause a global financial crisis? The last part of chapter four therefore describes the mechanisms and development of the subprime market as well as how it could foster a financial crisis of this magnitude.

This thesis analyses whether there has been an improvement in the private sector's ability to foresee the future policy rate in countries that have implemented inflation targeting. It investigates the central banks actual behaviour. Have the inflation targeting central banks actually been focusing more on keeping inflation close to its target or have they been more concern with closing the output gap? The final chapter deals with the cause of the financial crisis, is loose monetary policy or loose regulation to blame?

[6] The CPI has been growing around 3 per cent per year since 1983 (IMF's International Financial Statistics).

2 HAS INFLATION TARGETING LED TO IMPROVED PRIVATE SECTOR INTEREST RATE FORECASTS?

2.1 INTRODUCTION AND PURPOSE

As explained in section 1.2, the purpose of this chapter is to decide whether inflation targeting has improved the private sector's ability to forecast the policy rate set by the central banks. Inflation targeting countries have a publicly known monetary policy strategy that aims at reaching a set inflation target. The inflation targeting central banks have enhanced transparency and public communication. They publish their own policy rate forecasts and minutes from policy meetings. Under these circumstances it is interesting to estimate what effect this has had on the private sector's policy rate forecasts. The next section of this chapter describes monetary policy and the concept of inflation targeting, inflation forecast targeting and transparency. This section is followed by a presentation of previous research within the field of estimating how well expectations match the interest rate decision made by the central banks. The empirical analysis is carried out in section 2.4 and the results are displayed and further commented in the final part of this chapter.

2.2 MONETARY POLICY THEORY

2.2.1 POLICY RULES

Taylor (1993) introduces the well-known "Taylor Rule" as a simple instrument rule. His aim was to find a pattern of how the interest rate (the instrument of the central bank), the inflation target, its deviation and the output gap relate to each other in order to find a "preferred policy rule"[7]. The policy rule he found describes the US Federal reserve policy in previous years surprisingly well.

$$i_t = r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta(y_t - y_t^*) \qquad (2.1)$$

Where: i_t = nominal interest rate, in the US i.e. Federal Funds rate, at time t

r^* = the target level for the nominal interest rate

π_t = average inflation rate at time t

π^* = inflation rate target

[7] He is very clear to state that monetary policies cannot and should not be followed mechanically because there are factors and circumstances that cannot be measured and foreseen correctly.

y_t = actual output at time t

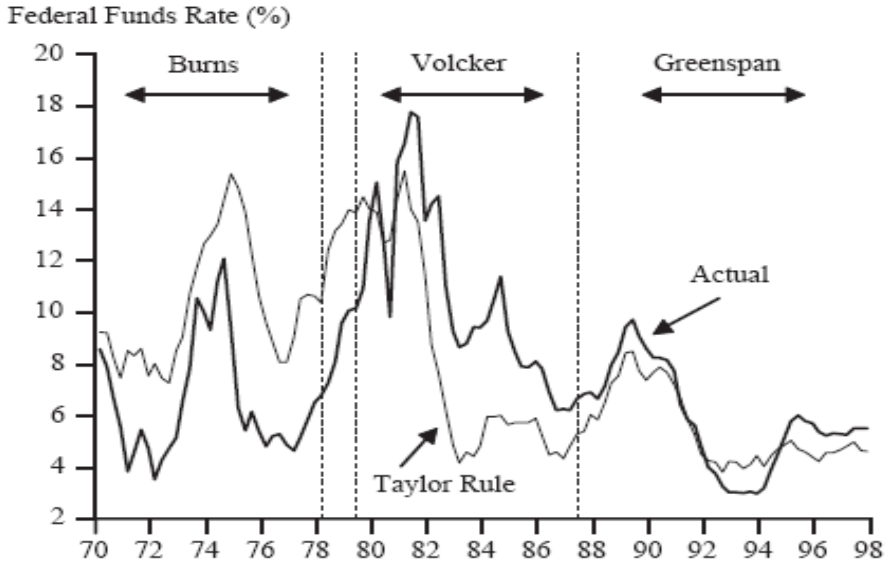
y_t^* = potential output at time t

Hence, the interest rate set by the central bank is possible to simply calculate once one knows the average inflation rate and target, output gap, and the equilibrium interest rate. This model has been widely tested empirically, especially, for the US. Below, Judd and Rudebusch (1998) test the following model where they include the factor, r^*, equilibrium real federal funds rate:

$$i_t = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5\left(\frac{y_t - y_t^*}{y_t^*} * 100\right) \qquad (2.2)$$

The result is graphically presented in figure 2.1 below. It shows how well the estimated "Taylor rule interest rate" has reflected the actual interest under three Federal Reserve Bank Chairmen managing the Federal Reserve from 1970 to 1998. Taylor uses the weights 0.5 which suggests that equal weight is put on keeping output and inflation at their target and potential levels respectively. Looking at the result in figure 2.1 it is obvious that this suggestion fits quite well with the Federal Reserve's monetary policy.

Figure 2.0.1 The Taylor rule estimated interest rate compared to the actual interest rate in the U.S.



Source: Judd and Rudebusch, Federal Reserve Bank San Francisco (1998)

Gerlach and Schnabel (1999) have also tested the Taylor rule using data from the EMU countries over the period 1990-1998 and found, with the exception of the period 1992-1993[8], that the average

[8] 1992-1993 was a period of time when Europe experienced major exchange rate turmoil.

interest rate has moved in accordance with the Taylor rule. In order to find statistically significant results when estimating the Taylor rule economists often have to lag the policy instrument i.e. the nominal interest rate, i_t. Remembering Friedman's result in 1972, where he found that it takes more than a year before the monetary policy instrument has an effect on inflation, having to use lags in this model is therefore not surprising.

2.2.2 INFLATION TARGETING

As earlier explained in the literature overview, inflation targeting implies that the monetary authorities' primary goal is to reach a previously decided level of the inflation rate. Inflation targeting is an easily understood concept that can be explained to and later closely monitored by the public. If a central bank enjoys credibility, earned by a good track-record, the financial market participants will have clear information about the set inflation target and also believe that the central bank will be able to steer the actual inflation to this level. Hence, the expected inflation level should equal lagged realised inflation[9] since monetary authorities cannot affect current inflation. Svensson (1997) calls this "imperfect control over inflation" and estimates the lag length to be 1.5-2 years. He concludes that in order to conduct inflation targeting one has to monitor and forecast future inflation.

2.2.3 INFLATION FORECAST TARGETING

Svensson (1997) presents a simple model with backward-looking expectations in order to demonstrate that inflation targeting implies inflation forecasting. In a paper by Schmidt-Hebbel and Tapia (2002) based on surveys conducted in 20 inflation targeting countries it is revealed that 12 out of the 20 countries use inflation forecasts as intermediate inflation targets when pursuing inflation targeting. Future inflation can be described by a Phillip's curve.

Phillip's curve: $$\pi_{t+1} = \pi_t + \alpha_1 y_t + \alpha_2 \kappa_t + \varepsilon_{t+1} \quad (2.3)$$

Today's inflation (π_{t+1}) depends on yesterday's inflation (π_t), output gap (y_t), an exogenous variable (κ_t), and a shock today (ε_{t+1}) that was not known yesterday. Aggregate demand can be described as follows:

[9] One must not forget the possibility of shocks that might hinder the central bank to hit the exact target.

$$y_{t+1} = \beta_1 y_t - \beta_2 (i_t - \pi_t) + \beta_3 \kappa_t + \eta_{t+1} \quad (2.4)$$

Today's output gap (y_{t+1}) depends on yesterday's output gap (y_t), the short-term interest rate minus inflation rate i.e. the real interest rate (i_t-π_t), an exogenous variable (κ_t) yesterday, and an i.i.d. shock today (η_{t+1}) that was not known yesterday.

$$\kappa_{t+1} = \gamma \kappa_t + \theta_{t+1} \quad (2.5)$$

Today's exogenous variable is described by an exogenous event yesterday plus an i.i.d. shock θ that occurs today. The coefficients $\alpha_{1,2}$ and $\beta_{1,2,3}$ are assumed to be positive, furthermore γ satisfies the condition $0 \leq \gamma \leq 1$.

In conclusion, today's inflation increases as yesterday's output gap and inflation increases. Output today is negatively affected by a raised interest rate yesterday.

$$i_t \rightarrow r_t \xrightarrow{1 period} y_{t+1} \xrightarrow{1 period} \pi_{t+2}$$

The policy instrument is the short-term interest rate (i_t) which affects the real interest rate ($r=i_t$-π_t) in the same period. Moving one period into the future the real interest rate (r_t) affects the output gap (y_{t+1}). By further moving an additional period into the future the output gap affects the inflation rate (π_{t+2}). Hence as previously investigated by Friedman (1972) and argued by Svensson (1997), the central bank has imperfect control over inflation in the sense that the effect of a changed interest rate is lagged by more than a year[10] or 2 periods (according to Svensson above). An important implication of this model is that the interest rate affects output negatively before it influences the inflation rate.

Suppose that a central bank pursues an inflation targeting policy. The objective of the central bank is to choose an optimal short-term interest rate over time i.e. $\{i_t\}_{\tau=t}^{\infty}$ that minimises today's expectations (E_t) conditional on the central bank's information available today, the discount factor (δ), and today's loss function.

$$E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} L(\pi_\tau) \quad (2.6)$$

The loss function is specified as follows.

[10] A lag that amounts to more than one year is found by Friedman (1972) and Batini and Nelson (2002).

$$L(\pi_t) = \frac{1}{2}(\pi_t - \pi^*)^2 \tag{2.7}$$

Where the central bank wishes to minimise the sum of expected squared and discounted future inflation (π_t) that deviates from the target (π^*).

Since the central bank has imperfect control over inflation, it can only aim at minimising the expected squared deviation based on information available when the interest rate is set and not on the realised squared deviation. Svensson, furthermore, includes output as an extension of this model in Svensson (1999). Then the objective of the central bank is to choose an optimal interest rate that minimises the squared deviation from the inflation target and potential output:

$$E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} L(\pi_\tau, y_\tau) \tag{2.8}$$

Where the extended loss function is defined as:

$$L(\pi_\tau, y_\tau) = \frac{1}{2}\left[(\pi_\tau - \pi^*)^2 + \lambda y_\tau^2\right] \tag{2.9}$$

λ represents the weight the central bank puts on trying to minimise the output gap in addition to the deviations of actual inflation from the inflation target. Svensson (1999) calls this flexible inflation targeting as long as the weight λ is not disproportionate. When λ is not included (as seen above) one could also say that $\lambda=0$, hence no weight is put on output stabilisation, then strict inflation targeting is pursued. Empirically it has been found that inflation targeting as well as non-inflation targeting countries focus their monetary policy on achieving inflation targets and to minimise output gaps. However, more weight is put on achieving the inflation target in inflation targeting countries than in those that pursue flexible inflation targeting (Schmidt-Hebbel and Tapia, 2002). This indicates that flexible inflation targeters are no "inflation nutters" as they may allow inflation to increase above its target if it can help economic growth in extraordinary situations.

2.2.4 TRANSPARENCY

In this thesis it is tested whether increased transparency leads to greater predictability of the central bank's policy decisions. It is important to acknowledge that there are different kinds of transparency. Lasaosa (2005) has identified three different kinds:

- First, *goal transparency* which is characterised by monetary authorities openly announcing their target.
- The second is *knowledge transparency* which is when a central bank releases information about the state of the economy and its forecasts.
- The third kind of transparency is *operational transparency*, which implies that central banks reveal how the policy decisions are made e.g. how the voting process is conducted.

Geraats (2002) has reviewed empirical and theoretical literature and concludes that the theoretical literature agrees that transparency is beneficial in the sense that it could reduce private sector uncertainty and enable the central bank to act with greater flexibility to stabilise output volatility and economic shocks. Although, it depends on which model is being used, for example in a Lucas supply function monetary policy is only effective if changes come as a surprise [11] (Carpenter, 2004). On the other hand, if a New Keynesian model is used to model the monetary policy, then the surprise effect is not as important.

Empirically there seems to be consensus that transparency is desirable and tends to be beneficial for the same reasons as mentioned above (Geraats, 2002). Carpenter (2004), further points out that the academic literature gives little guidance about the practical aspects of transparency e.g. which kind of transparency should be implemented and how. Knowledge transparency can cause asymmetric information problems if central banks publish their forecasts and inflation reports based on information that is better than the information held by the public. In this case the public holds less information than the central banks and may underestimate risks and uncertainty in the revealed information and in the end the published forecasts and reports can have destabilising effects. Schmidt-Hebbel and Tapia (2002) investigate the central banks' main communication which is the so called inflation reports[12]. They reason that the reports are pieces of incomplete information since the central banks only reveal the final conclusions. How the conclusions are drawn (i.e. what methods and analytic process that are used) is not extensively explained. Hence, the public has less

[11] Since inflation expectations are formed at the beginning of any period in the Lucas supply function, current policy actions affect the future inflation expectations.

[12] See appendix 1 for further information on inflation reports and inflation targeting countries.

information than the central banks. Furthermore they also find that only 12 out of 20 inflation targeting countries derive their monetary policy decisions from their inflation reports. Operational transparency may confuse the public. Assume that central bank members have different opinions and individual forecasts that they announce in advance of the policy meetings- in addition the voting process is also revealed after the policy meetings. These different signals might cause confusion. Lasaosa (2005) investigates how the financial market reacts to macroeconomic announcements and to monetary policy changes in the UK. She finds that after 1997 the reactions to macroeconomic announcements have increased but the reactions to interest rate changes have not decreased statistically significant. Under inflation targeting one would assume that the reactions to interest rate changes would have decreased. However, in the UK this is not true and Lasaosa (2005) motivates this by the fact that the nine monetary policy committee (MPC) members present their individual opinions before the MPC meetings. In doing so, the market is given different signals which cause confusion and uncertainty about the future actions of the MPC. Carpenter (2004), who stresses the benefits of transparency, reaches the conclusion that the benefits of transparency can only be achieved if central banks avoid confusion by using clear communication.

2.3 PREVIOUS RESEARCH

This section considers earlier research on how well the private sector and financial market assesses the future official interest rate, hence actions taken by the central bank. The financial markets are sensitive to changes in the official interest rate since this is what banks pay when they borrow from the central bank and therefore it affects the whole financial market. One way to measure market expectations is to monitor the prices and rates of interest rate futures.

2.3.1 INTEREST RATE FUTURES

The trade with interest rate futures started in the U.S. in October 1988. One of the most liquid and short-term interest rate futures is the 30-day fed funds futures contract. The underlying asset for this contract is the average daily effective federal funds rate for the delivery month. The price for this contract on the settlement day is 100 minus the average effective federal funds rate. For example assume that the settlement price of a future is 96.5, this means that the effective fed funds rate was (100-96.5=3.5) 3.5 per cent on average over the last 30 days. Federal fund futures can be used for a variety of purposes, but there are three major groups of traders. First the Proprietary traders at

banks and hedge fund managers. They trade with fed fund futures based on their expectations for future monetary policy developments i.e. speculative reasons. Secondly there are the fixed-income portfolio managers, also called hedgers. Fed fund futures offer an opportunity to hedge against risks that the portfolio manager has taken on by investing in other fixed income assets with diverse duration. The third group is the treasury department at banks. They are exposed to shifts in the short-term interest rate and fed fund futures help them to stabilise the cost of overnight transactions in the cash fed funds market (Chicago Board of Trade, 2003).

Below follows an example of how a bank protects itself against interest rate changes, inspired by Söderström (2001) and Carlson, McIntire and Thomson (1995).

Assume that a bank holds $80 million in federal funds. The economists at the bank expect the Federal Reserve to raise the fed funds rate. The current rate is 5.25 per cent. By selling 16 futures contracts (16·$5 million = $80 million)[13] the bank has hedged itself against any losses incurred from an increase in the fed funds rate. If the funds rate was to increase to 5.45 per cent this would cost the bank 5.45%·30/360·$80 million = $363,333 in interest costs over one month. However at maturity the futures price has fallen from 94.75 to 94.55. Since the contract size is $5 million each bp (basis-point) change in the fed funds rate moves the price of the contract by one tick i.e. $41.67 (i.e. 0.01%·30/360·$5 million). In our case the fed funds rate increased by 20bp and by selling 16 futures the bank gains 16·20·$41.67 = $13,334.4. Hence the net interest rate cost is $350,000 which is an effective interest rate cost of 5.25 per cent. A speculator that assumes that the Federal Reserve intends to decrease interest rates would buy federal funds futures at a price of 94.75 (=100-5.25). When the Fed has lowered the funds rate to 5.05 per cent he/she can sell the futures contracts and profit 20·$41.67 = $833.40 for each sold contract as the price for the futures contracts rises as the fed funds rate is lowered.

2.3.2 Predictive power of federal funds futures

Extensive research has been conducted on the predictive power of federal funds futures on the realised future federal funds rate in the U.S. One of the main reasons for the increased interest in the behaviour of the Federal Reserve is its increased transparency. Until 1994 the market had no information about the intended federal funds rate. It was only possible to interpret the Federal Open Market Committee (FOMC) operations and make a qualified guess which decisions and changes that had been or would be made. In 1994 the FOMC began to announce the policy actions and decisions

[13] One Fed funds future contract at the CBOT carries a notional of $5 million.

on the same day as the meeting. Three years later a numerical value for the intended federal funds rate was added to the announcements. Since May 1999 press statements are released after each meeting and nowadays include information on expected risks of increased inflation and economic weaknesses over the short-term future (Poole et al., 2002).

Carlson et al. (1995), state that the price of fed funds futures basically embodies a forecast of the monthly average federal funds rate. The fed funds rate is set by the Federal Reserve through its open market operations in which it decides on how much of the reserves will be supplied to the market. In this sense the fed funds rate is the equilibrium of supply and demand of the reserves. The Desk at the Federal Reserve, who conducts the open market operations, does not exactly know the level of required reserves or how large the excess demand for reserves is. Hence the actual federal funds rate may differ from the intended federal funds rate from day to day. The decision to take a long or short (buy or sell) position in federal funds futures is based on expectations of future monetary policy actions.

Carlson et al. (1995) measure the predictive accuracy of fed fund futures to forecast the effective fed funds rate. They show how the monthly average futures rates correspond to the fed funds rate. The predictive power is fairly accurate; on average the futures show a mean absolute deviation of less than 6bp[14] on a horizon of one month. In comparison, this is about the same as the average deviation of the fed funds rate and its intended rate over one month. The data also demonstrate that the deviations between the futures and fed fund rate decreases steadily as the expiration date of the contract approaches. In addition the predictive accuracy seems to diminish as the contract horizons become longer. Finally Carlson et al. (1995) choose to test whether the predictability of the fed funds futures is better than a naïve forecasting model and an estimated univariate model. The naïve or also called random walk model assumes that the past interest rate is able to forecast the current interest rate. Changes in the fed funds rate occur randomly and are permanent. The estimated univariate model assumes that interest rate changes are permanent and if one change has occurred in one period then the model expects it to occur again in a future period. The univariate model is estimated by the authors using data from 1954 to 1988. The outcome shows that all three approaches predict the fed funds rate to be higher than it actually has been. When examining the mean squared errors (MSEs)[15] the futures show a more accurate prediction of the future fed funds rate than the other approaches. The authors conclude that with this short period of fed funds futures trading; futures are a useful predictor for the future fed funds rate, especially in the short run. A large number of studies

[14] bp stands for basis point and is 1/100 of one per cent.

[15] The MSE measures the distribution of the forecast errors and indicates the uncertainty that accompanies the prediction.

use monthly averages or end of the month federal funds futures prices or rates to predict the fed's actions over the same horizon. When using monthly averages it is possible to cancel out the daily noise that tends to affect the futures market (Poole et al., 2002). Federal funds futures can be bought and sold during the contract month. This implies that the price of a funds futures contract reflects the prevailing federal funds rate that is known and the expected funds rate that is not known. The futures contract contain the market's expectations of the realised future funds rate and as the contract moves closer to maturity these expectations get more and more accurate. This is also found by Carlson et al. (1995). Based on these considerations Söderström (2001) examines how useful current month future prices are when measuring monetary policy expectations from one day to the next. The data on the prices and rates of the federal funds futures is daily and comes from the Chicago Board of Trade and the federal funds rate data comes from the Federal Reserve Bank of St. Louis. The sample ranges over almost 10 years from October 3rd 1988 to March 6th 1998. Söderström (2001) estimates two similar equations, the first one for the time period before 1994 and a second with observations from the time period after 1994. With OLS he estimates how the expected funds rate (measured partly by the future rate, see Söderström (2001) p. 5 equation 7 predicts the target change on the next day. After adjusting for serial correlation Söderström finds that the expected funds rate is a poor predictor of changes in the funds target. The results improve slightly in the second time period. The reason for the poor result might be that the futures rate is not only moved by monetary expectations. In order to solve this problem he chooses to carry out the estimation only when the federal funds rate was changed. The outcome shows a much better fit, especially for the time period from 1994 to 1998. Söderström (2001) continues his estimation by adding dummies that allow for the intercepts to vary across the different months and the last three days of the trading month. He finds that the expected funds rate is further away from the future funds rate during June, July, September and December as well as the last days of the trading month. Söderström's (2001) conclusion is that federal funds futures appear to be a useful measure of market expectations in the short run, but an adjustment for monthly variations and trading days should be made.

Poole et al. (2002) use the changes in the fed funds futures as a proxy in order to measure unexpected changes in the funds rate target when investigating how well the market can foresee the fed interest rate changes made by the FOMC. They analyse each unanticipated and anticipated rate change by observing the fed funds future that reflects the expectations of the market. By employing OLS, Error-in-variable techniques[16] as well as case studies that investigate each anticipated and

[16] When simply using the variation in federal funds futures as a proxy for unexpected target changes one has to be careful since not only Fed actions can cause the federal funds future rates to change. Idiosyncratic and other shocks might also cause the rate of the federal funds future to vary. By reducing the number of variables that incorporates the measurement error (the so called Errors-in-Variable technique) it is possible to get around this problem.

unanticipated Fed action, they find that there has been a change in market expectations before and after 1994. Hence, there is a smaller number of unexpected interest changes after 1994 and the market has been better at forecasting policy changes due to the increased transparency of the Federal Reserve Bank. The result reveals that not only is the market better at anticipating policy actions after 1994, it is also able to predict the actions further in advance.

Lange et al. (2003) investigate how well the financial market anticipates monetary policy changes in the U.S. over the years 1983 to 2000 by using basic unstructured regressions. The data used are monthly averages and the aim is to find a correlation between the federal funds rate and changes in market interest rates. They test the ability of federal funds futures to predict changes in the federal funds rate by looking at the found R^2-value and the estimated (significant) coefficient. Since fed fund futures were introduced in 1988, monthly data is only available from 1989. They test the predictability of futures for horizons ranging from 1 up to 3 months. In order to find changes of how well the futures forecast the fed funds rate they divide the data into two time-periods: (i) 1989:5 to 1994:1 and (ii) 1994:2 to 2000:10. The R^2-value for time period (i) lies between 0.32 and 0.33 for 1 to 3 month fed funds futures. In the second time period the R^2-values have risen considerably to levels ranging between 0.7 and 0.8.

Swanson (2004) updates the econometric modelling of Lang et al. (2003) with data beyond 2000:10. He finds that the result (R^2-values) in 2001 and 2002 deteriorate dramatically. The Federal Reserve Bank began a sequence of interest rate cuts in January 2001 and at the same time the whole U.S. economy experienced instability and an uncertain future as well as the attacks on the World Trade Center in September 2001 which caused further instability. Hence during 2001 and 2002 economists and participants on the federal funds futures markets were experiencing difficulties to accurately forecast the future federal funds rate. Furthermore he forms a hypothesis which suggests that it is more difficult to forecast a volatile federal funds rate than a stable one. To test this hypothesis, he finds a “momentum” variable that captures the federal funds rate volatility. The momentum variable is then regressed on the fed funds futures. The outcome demonstrates that higher momentum leads to a poorer fed funds futures predictability of the future fed funds rate.

To conclude this section it can be stated that much research has been conducted in the U.S. on the capability of the private market to foresee interest rate changes as the Federal Reserve Bank has become more transparent. As mentioned before, the inflation targeting framework does not automatically lead to higher transparency; however, this has been the case in the inflation targeting countries included in this paper thesis.

2.3.3 DATA SELECTION

Data on the generic interest rate futures rate will be used as a proxy for the expected interest rate in the empiric analysis. The generic rate is used because it gives the rate of contract in a particular contract month and it then automatically rolls into the next month. This method helps to create a continuous time series which can be used for data analyses. Not many countries offer 30-days interest rate futures and therefore will the 90-day or 3-month interest rate futures be used in this study. The data on inflation, policy interest as well as the federal funds rate is collected from Bloomberg. Since the countries introduced interest rate futures at different points in time, the time series will be of varying length in the different countries and regions. Some of the inflation targeting countries presented in the appendix do not trade domestic interest rate futures. These countries will be excluded from the investigation. Three countries that do not conduct explicit inflation targeting will be tested and used as a reference group when analysing the results of the tests in the inflation targeting countries. These countries or regions are Japan, the U.S., and the Eurozone. Both Japan and the Eurozone have 3-month interest rate futures, but in the U.S. 3-month interest rate futures are not traded and therefore will the 1-month or 30-days interest rate futures be used in the test for the U.S. instead. The 30-days interest rate futures will probably be better at forecasting the future interest rate since the forecast horizon is shorter. Carlson et al. (1995) have found that the fed fund futures better predict the fed funds rate when the time horizon is shorter. Long-run relationships are often disturbed by unforeseen events. The latest financial crisis is one example of an unforeseen event. It is said to be the most severe since the great depression and using data from this time period will probably disturb the estimators. The data up until the financial crisis defined by the date when Bear Sterns filed for bankruptcy which was March 13th 2008 will be used in the econometric estimation. There will probably also be somewhat misleading results during the year after the September 11th attacks in 2001 and this will be considered in the analysis of the results

2.4 EMPIRICAL ANALYSIS

The purpose of this chapter is to estimate how well the private sector can forecast the policy interest rate and interest rate futures will be used as a proxy variable for the interest rate expectations. Gürkaynak et al. (2007) among many other economists, find that the financial instrument that best captures the expectations of future monetary policy changes (hence the future interest rate) is the federal funds futures, also called interest rate futures in other countries than the U.S. The rate on the

interest rate futures is closely linked to the realised average official interest rate for the particular calendar month in question.

2.4.1 EMPIRICAL FRAMEWORK

This section describes the model that Gürkaynak et al. (2007) have developed. It is also the model that will be employed in the empirical tests below.

Gürkaynak et al. (2007) start by assuming the following:

$$r^{m}_{t,t+k} = E_t\left[\prod_{j=t}^{t+k-1}(1+ ff_j)-1\right] + \Phi^{m}_{t,t+k} \qquad (2.10)$$

i.e. the rate of return ($r^{m}_{t,t+k}$) on a market instrument (*m*) from day (*t*) today (*t+k*) is equivalent to the expected rate of return on an investment strategy of rolling over[17] overnight loans in the federal funds market from day (*t*) today (*t+k*) (where ff_j is the overnight official interest rate on day *j*, plus the risk premium $\Phi^{m}_{t,t+k}$). The risk premium is usually assumed to be constant over time in the literature by referring to the "expectations hypothesis" where it only depends on the market instrument and its maturity.

Continuing by denoting the rate of return on the rolling over overnight loans in the following manner: $\overline{ff}_{t,t+k} = \left[\prod_{j=t}^{t+k-1}(1+ ff_j)-1\right]$ and letting the risk premium be included as the regression residual[18] gives the forecasting regression[19]:

$$\overline{ff}_{t,t+k} = \alpha + \beta r^{m}_{t,t+k} + \varepsilon_t \qquad (2.11)$$

The important result of this regression is the goodness of fit (R^2-value) i.e. how well the market instrument (in this case the interest rate future) can forecast the interest rate set by the central bank.

[17] "Rolling over" means that a bond holder uses the regained par amount and any possible gains from a maturing bond to buy a new bond.

[18] The risk premium for federal funds futures is by far the smallest for all compared financial instruments (Gürkaynak, 2006).

[19] This is a standard forecasting regression that is widely used in the literature (Gürkaynak, 2006).

In order to test forward instruments the regression needs to be modified. In the case of interest rate futures they predict the official interest rate at some future date stated by (*t+j*). Hence the rate of return on security (*m*) on day (*t*) for a loan that begins on day (*t+j*) and ending on day (*t+j+k*), is $r^{m}_{t,t+j,t+j+k}$.

$$\overline{ff}_{t+j,t+j+k} = \alpha + \beta r^{m}_{t,t+j,t+k} + \varepsilon_t \tag{2.12}$$

When estimating regression 2.12 Gürkaynak et al. (2007) run into an econometric problem. The dependent and independent variables in the equation are co-integrated i.e. they both follow a similar trend. This trend, the co-integration vector, only shows the variables' long-run relation and not their short-run behaviour that is of interest in this study. The Johansen's co-integration test as well as Dickey-Fuller unit root test has been carried out and the results show that the same problem arises in data in this study. By subtracting the current level of the official interest rate (ff_t) from the values of variables on both sides it is possible to get around this problem.

$$\overline{ff}_{t+j,t+j+k} - ff_t = \alpha + \beta(r^{m}_{t,t+j,t+k} - ff_t) + \varepsilon_t \tag{2.13}$$

In this thesis interest rate futures will be used to estimate the private sector interest rate forecasts. Hence, equation 2.13 can be modified once more. Short and long-term interest rates predict the official interest rate over a short or long time period which begins at day (*t*). Interest rate futures predict the official rate at some other future date (*t+k*) and can be denoted by $f_{t,t+k,n}$, i.e. on day t an interest rate future that predicts the interest rate starting on day (*t+k*) with a maturity of day (*t+k+n*) is bought. This gives equation 2.14:

$$\overline{ff}_{t+k,t+k+n} - ff_t = \alpha + \beta(f_{t,t+k,n} - ff_t) + \varepsilon_t \tag{2.14}$$

where ε_t denotes the forecast error term.

When using this regression to estimate how well the federal funds futures can predict the federal funds rate, Gürkaynak et al. (2007) replace the dependent variable with the arithmetic average of the federal funds rate over the expiration month since the federal funds future contracts are settled on this basis. The policy interest rates in the countries intend to investigate have been quite stable and therefore the average interest will not be used in the tests. Furthermore the reasoning in Söderström (2001) is followed and data with daily observations is used. In the first estimation the rate of the interest rate future today is matched with the actual future interest rate in three months from today. This results in the following regression:

$$ff_{t+90} - ff_t = \alpha + \beta(f_t - ff_t) + \varepsilon_t \qquad (2.15)$$

2.4.2 EMPIRICAL ESTIMATIONS AND ANALYSIS

In order to see changes over time the time series is divided into time periods ranging from 4 to 10 years depending on different circumstances. In the countries where inflation targeting was introduced after trading with interest rate futures began, dummies that represent the introduction of inflation targeting are included in the equation. In the case of the UK an "independence" dummy has also been used in order to test if the independence of the Bank of England made a difference to its credibility and predictability by the financial market. The remaining inflation targeting countries' central banks gained independence when inflation targeting was introduced with the exception of the UK and therefore it will be tested whether this has had an effect.

Table 2.1 Estimating how well interest rate futures predict the policy interest rate

Country	Time Period	R^2	α	β_1	β_2 Dummy	t-stat	SIC	Std. Err.	F-Stat
UK	Mar 1988- Mar 2008	0.19	0.08	-0.56		-8.68	1.236	0.06	11445
1992	Mar 1988-Mar 1992	0.18	-0.17	-0.75		-4.66	2.33	0.16	216
	Mar 1992- Jun 1997	0.29	0.19	-0.69		-7.34	1.16	0.09	506
	Jun 1997- Mar 2008	0.32	0.1	-0.49		-10.46	-0.29	0.05	1330
IT Dummy	Mar 1988- Mar 2008	0.24	-0.16	-0.81	0.31	3.56 (d)	1.171	0.09 (d)	796
Independence Dummy	Mar 1988- Mar 2008	0.19	0.04	-0.58	0.08	1.81 (d)	1.233	0.04 (d)	595
New	Jun 1991- Mar 2008	0.24	-0.28	0.76		10.98	2.48	0.07	1202
Zealand	Jun 1991- Jun 1995	0.39	-0.29	1.07		15.55	2.90	0.07	641
1989	Jun 1995- Jun 2001	0.15	-0.34	0.74		5.63	2.95	0.13	235
	Jun 2001- Mar 2008	0.17	-0.05	0.27		6.01	0.19	0.04	344
Jun 1991- Mar 2008 excl. Jun 1997- Mar 1999		0.33	-0.22	0.81		12.25	2.08	0.07	1725

Country	Time Period	R^2	α	β_1	β_2 Dummy	t-stat	SIC	Std. Err.	F-Stat
Canada	Jun 1993- Mar 2008	0.74	-0.19	0.81		22.9	0.68	0.04	10139
1991	Jun 1993- Dec 1998	0.71	-0.32	0.86		18.0	1.46	0.05	3254
	Dec 1998- Dec 2002	0.88	-0.17	0.75		29.5	-0.52	0.03	7257
	Dec 2002- Mar 2008	0.85	-0.1	0.79		34.96	-1.31	0.02	7309
Australia	Jun 1989- Mar 2008	0.52	-0.19	0.85		13.0	1.03	0.07	5167
1993	Jun 1989- Mar 1993	0.34	-0.5	0.78		8.9	1.82	0.09	482
	Mar 1993- Mar 1998	0.37	-0.13	0.59		5.4	1.12	0.11	751
	Mar 1998- Mar 2008	0.56	-0.05	0.67		13.2	-0.60	0.05	3329
IT dummy	Jun 1989- Mar 2008	0.59	-0.54	0.67	0.45	6.64 (d)	0.87	0.07 (d)	3440
Sweden	Dec 1992- Dec 2007	0.56	-0.18	0.55		15.72	0.33	0.03	500
	Dec 1992- Dec 2007	0.56	-0.18	0.55		15.72	0.33	0.03	500
1993	Dec 1992- Dec 1997	0.61	-0.30	0.50		15.84	0.87	0.03	1941
	Dec 1997- Dec 2002	0.37	-0.18	0.52		11.59	-0.11	0.05	716
	Dec 2002- Dec 2007	0.69	-0.12	0.90		19.27	-0.68	0.05	2813
Japan	Sep 1989- Mar 2007	0.1	-0.09	0.13		4.8	0.33	0.03	501
	Sep 1989- Sep 1993	0.6	-0.77	0.46		15.62	0.75	0.35	1543
	Sep 1993- Sep 1997	0.03	-0.13	0.14		1.84	-0.13	0.08	28
	Sep 1997- Sep 2002	0.0005	-0.02	0.01		0.58	-2.76	0.01	0.6
	Sep 2002- Mar 2007	0.67	0.01	0.97		10.1	-2.9	0.1	2292
US	Mar 1989- Mar 2008	0.03	-0.07	0.55		2.44	0.82	0.22	106
Mar 1994- Mar 2008 excl. Sep 2001- Sep 2002		0.04	-0.01	0.84		2.91	0.78	0.29	152
	Mar 1989- Mar 1994	0.002	-0.2	-0.12		-0.46	0.43	0.26	1.9
	Mar 1994- Mar 2001	0.03	0.03	0.70		3.31	0.43	0.21	61
	Mar 2001- Mar 2008	0.04	-0.06	0.87		1.82	1.02	0.48	66
	Mar 2003- Mar 2008	0.06	0.04	1.02		1.46	0.80	0.70	73

Country	Time Period	R^2	α	β_1	β_2 Dummy	t-stat	SIC	Std. Err.	F-Stat
Eurozone	Jan 1999- Mar 2008	0.57	-0.12	0.62		14.95	-0.93	0.04	3065
	Jan 1999- Mar 2003	0.65	-0.13	0.70		16.95	-0.61	0.04	1954
	Mar 2003- Mar 2008	0.36	-0.06	0.41		6.27	-1.45	0.07	729

Note: Estimated by using Newey-West heteroscedastic and autocorrelation consistent standard errors. The equation used is 2.15. IT stands for Inflation target.
Source: Bloomberg

In the next table the residuals are tested in accordance to the basic assumptions of the OLS method.

By using the Breusch-Godfrey test with lags up to the 50th order: $u_t = \tau_1 u_{t-1} + \tau_2 u_{-2t} + \cdots + \tau_{50} u_{t-50} \varepsilon_t$ it is found that there exists autocorrelation among the residuals. It is not possible to reject the null hypothesis: $H_0 : \tau_1 = \tau_2 = \cdots = \tau_{50} = 0$, when investigating the residuals further in table 2.2 below, which means that there is positive autocorrelation in the residuals. Secondly the White heteroscedasticity test is applied to check whether the residuals have a constant variance. The null hypothesis assumes no heteroscedasticity and it can be accepted in all countries and time periods except in Japan and New Zealand where a heteroscedasticity problem exists in the data from 1989 to 1993 and from 1991 to 2001 respectively. Table 2.2 gives further statistic details on the residuals.

Table 2.2 Analysing the residuals

Country	Time Period	Mean $E(\varepsilon_t)$	var(ε_t)	White Hetero-sked.	D-W d-stat	Breusch-Godfrey	Skew-ness	Kurt-osis	Jarque-Bera normality
						Autocorr.			
UK	Mar 1988- Mar 2008	0	0.20	0.00%	0.073	1lag	-0.91	13.12	22095.61
1992	Mar 1988-Mar 1992	0	0.60	0.00%	0.074	1lag	-0.55	3.98	88.62
	Mar 1992- Jun 1997	0	0.18	0.00%	0.137	1lag	2.14	13.55	6816.18
	Jun 1997- Mar 2008	0	0.04	0.00%	0.085	1lag	0.99	5.90	1450.61
IT Dummy	Mar 1988- Mar 2008	0	0.19	0.00%	0.086	1lag	-0.10	11.49	15070.44
Indep.		0							
Dummy	Mar 1988- Mar 2008		0.20	0.00%	0.075	1lag	-0.72	12.86	20750.30
New	Jun 1991- Mar 2008	0	0.70	12.26%	0.067	1lag	0.04	11.89	13033.72
Zealand	Jun 1991- Jun 1995	0	1.10	42.84%	0.122	1lag	2.15	13.30	4659.23
1989	Jun 1995- Jun 2001	0	1.06	6.53%	0.042	1lag	-1.25	4.93	589.92
	Jun 2001- Mar 2008	0	0.07	0.00%	0.023	1lag	-0.25	4.12	102.13
Jun 1991- Mar 2008 excl.		0							
Jun 1997- Mar 1999			0.46	1.69%	0.087	1lag	1.81	19.28	41221.97
Canada	Jun 1993- Mar 2008	0	0.12	0.00%	0.098	1lag	-0.13	11.89	12039.14
1991	Jun 1993- Dec 1998	0	0.25	0.00%	0.068	1lag	0.28	7.17	1001.93
	Dec 1998- Dec 2002	0	0.03	0.00%	0.147	1lag	-0.40	3.34	31.69
	Dec 2002- Mar 2008	0	0.02	0.64%	0.145	1lag	-0.64	4.77	258.48

Country	Time Period	Mean $E(\varepsilon_t)$	$var(\varepsilon_t)$	White Hetero-sked.	D-W d-stat	Breusch-Godfrey	Skew-ness	Kurt-osis	Jarque-Bera normality
Australia	Jun 1989- Mar 2008	0	0.16	0.00%	0.057	1lag	-0.98	5.63	2156.76
1993	Jun 1989- Mar 1993	0	0.35	0.00%	0.078	1lag	0.15	2.69	7.75
	Mar 1993- Mar 1998	0	0.18	0.00%	0.039	1lag	0.44	4.77	203.37
	Mar 1998- Mar 2008	0	0.03	0.00%	0.057	1lag	-0.66	4.46	414.14
	Jun 1989- Mar 2008	0	0.14	0.00%	0.061	1lag	-0.06	5.78	1550.59
Sweden	Dec 1992- Dec 2007	0	0.09	0.00%	0.037	1lag	-0.96	4.38	865.64
1993	Dec 1992- Dec 1997	0	0.14	0.00%	0.039	1lag	-0.67	3.21	94.40
	Dec 1997- Dec 2002	0	0.05	0.00%	0.037	1lag	-0.18	2.70	11.30
	Dec 2002- Dec 2007	0	0.03	0.00%	0.073	1lag	-0.34	3.82	58.98
Japan	Sep 1989- Mar 2007	0	0.08	0.00%	0.029	1lag	-1.07	5.84	2298.40
	Sep 1989- Sep 1993	0	0.12	11.60%	0.056	1lag	0.42	2.13	61.29
	Sep 1993- Sep 1997	0	0.05	0.32%	0.038	1lag	-2.23	6.58	1351.47
	Sep 1997- Sep 2002	0	0.00	0.00%	0.024	1lag	-2.82	9.71	3950.21
	Sep 2002- Mar 2007	0	0.00	0.00%	0.076	1lag	0.20	5.76	367.97
U.S.	Mar 1989- Mar 2008	0	0.13	0.00%	0.025	1lag	-0.91	4.86	1346.86
Mar 1994- Mar 2008									
excl. Sep 2001- Sep 2002		0	0.13	0.00%	0.029	1lag	-1.27	6.09	2144.39
	Mar 1989- Mar 1994	0	0.09	0.00%	0.045	1lag	-0.78	3.62	145.69
	Mar 1994- Mar 2001	0	0.09	0.01%	0.035	1lag	-0.43	5.38	458.13
	Mar 2001- Mar 2008	0	0.16	0.00%	0.024	1lag	-1.51	5.38	1063.67
	Mar 2003- Mar 2008	0	0.13	0.00%	0.031	1lag	-2.16	9.33	3031.90
Eurozone	Jan 1999- Mar 2008	0	0.02	0.00%	0.102	1lag	-0.74	4.78	525.68
	Jan 1999- Mar 2003	0	0.03	0.00%	0.105	1lag	-0.43	3.89	68.89
	Mar 2003- Mar 2008	0	0.01	0.00%	0.089	2lags	-0.97	4.54	328.91

Source: Bloomberg

It is plain to see that there is autocorrelation among the residuals. In all cases except the last the autocorrelation order is one lag. In order to remedy this problem economists generally add the lagged value of y (i.e. y_{t-1}) to the independent variables on the right hand side; creating a AR(1) model.

$$ff_{t+90} - ff_t = \alpha + \beta_1(f_t - ff_t) + \beta_2(ff_{t+90} - ff_t)_{-1} + \varepsilon_t \qquad (2.16)$$

This method is also called the Cochrane-Orcutt procedure.

Table 2.3 Estimating how well interest rate futures predict the policy interest rate by using AR(1)

Country	Time Period	R^2	α	β_1	β_2	β_3 Dummy	SIC	D-W stat	F-Stat
UK	Mar 1988- Mar 2008	0.96	0.02 (0.2)	0.22 (15.8)	0.98 (397.7)		-1.88	2	22.74
1992	Mar 1988-Mar 1992	0.98	0.03 (10.7)	0.27 (10.7)	0.99 (220.4)		-1.24	1.9	20929
	Mar 1992- Jun 1997	0.93	0.13 (1.18)	0.06 (1.57)	0.97 (135.1)		-1.20	2.5	8643
	Jun 1997- Mar 2008	0.97	-0.03 (-0.3)	0.31 (20.2)	0.99 (379.3)		-3.44	2.0	26711
IT Dummy	Mar 1988- Mar 2008	0.96	0.03 (0.2)	0.22 (15.8)	0.98 (397.7)	-0.01 (0.14)	-1.87	2.3	44665
Independence Dummy	Mar 1988- Mar 2008	0.96	0.03 (0.3)	0.22 (15.8)	0.98 (396.9)	-0.02 (0.3)	-1.87	2.3	44666
New	Jun 1991- Mar 2008	0.95	-0.32 (3.1)	0.89 (54.1)	0.96 (240.0)		-0.25	2.1	37791
Zealand	Jun 1991- Jun 1995	0.93	-0.27 (1.3)	0.92 (26.6)	0.94 (83.7)		0.79	2.0	6121
1989	Jun 1995- Jun 2001	0.97	-0.36 (1.3)	0.88 (31.4)	0.98 (184.6)		-0.29	2.2	19641
	Jun 2001- Mar 2008	0.98	-0.08 (1.0)	0.43 (17.6)	0.99 (221.6)		-3.52	2.0	38293
Jun 1991- Mar 2008 excl. Jun 1997- Mar 1999		0.94	-0.24	0.88 (51.0)	0.96 (196.3)		-0.40	2.1	29501
Canada	Jun 1993- Mar 2008	0.99	-0.1 (1.0)	0.36 (29.2)	0.99 (358.6)		-2.29	2.0	133717
1991	Jun 1993- Dec 1998	0.99	-0.1 (0.4)	0.35 (17.7)	0.99 (235.1)		-1.65	2.0	51403
	Dec 1998- Dec 2002	0.99	-0.15 (2.1)	0.44 (17.2)	0.97 (128.7)		-2.59	2.15	32541
	Dec 2002- Mar 2008	0.99	-0.04 (0.5)	0.33 (15.0)	0.99 (181.6)		-3.54	1.9	39397
Australia	Jun 1989- Mar 2008	0.98	-0.18 (3.1)	0.56 (46.6)	0.98 (320.5)		-1.96	2.0	97109
1993	Jun 1989- Mar 1993	0.95	-0.54 (4.0)	0.70 (26.7)	0.96 (108.8)		-0.77	1.9	9151
	Mar 1993- Mar 1998	0.98	-0.05 (0.3)	0.24 (10.3)	0.99 (212.6)		-2.29	2.0	29822
	Mar 1998- Mar 2008	0.98	0.01 (0.2)	0.25 (17.8)	0.99 (301.5)		-3.77	2.1	69659
IT dummy	Jun 1989- Mar 2008	0.98	-0.38 (-4.9)	0.55 (47.1)	0.97 (294.8)	0.25 (3.4)	-2.02	2.0	68516

Country	Time Period	R^2	α	β_1	β_2	β_3 Dummy	SIC	D-W stat	F-Stat
Sweden	Dec 1992- Dec 2007	0.99	-0.10 (1.9)	0.26 (25.9)	0.98 (404.5)		-3.12	2.0	138597
1993	Dec 1992- Dec 1997	0.99	-0.18 (1.8)	0.21 (14.5)	0.98 (249.3)		-2.67	2.1	53363
	Dec 1997- Dec 2002	0.98	-0.12 (1.4)	0.26 (13.3)	0.99 (208.7)		-3.56	1.9	30311
	Dec 2002- Dec 2007	0.98	-0.06 (1.2)	0.56 (22.2)	0.98 (157.9)		-3.45	2.0	31831
Japan	Sep 1989- Mar 2007	0.98	-0.20 (2.1)	0.44 (34.0)	0.99 (541.1)		-3.35	2.0	94335
	Sep 1989- Sep 1993	0.98	-0.75 (7.6)	0.44 (16.5)	0.97 (131.8)		-2.14	1.9	22670
	Sep 1993- Sep 1997	0.97	-0.19 (2.2)	0.55 (19.9)	0.98 (197.4)		-3.61	2.0	16089
	Sep 1997- Sep 2002	0.98	-0.02 (0.7)	0.07 (6.5)	0.99 (235.7)		-6.51	2.0	26252
	Sep 2002- Mar 2007	0.98	0.02 (1.2)	0.66 (25.3)	0.97 (138.0)		-5.49	1.9	25080
U.S.	Mar 1989- Mar 2008	0.98	-0.09 (1.4)	0.52 (36.4)	0.99 (430.0)		-2.87	2.0	94549
Mar 1994- Mar 2008 excl. Sep 2001- Sep 2002		0.97	-0.06 (0.7)	0.55 (31.7)	0.99 (345.9)		-2.85	2.1	62350
	Mar 1989- Mar 1994	0.96	-0.21 (2.1)	0.38 (12.8)	0.98 (183.8)		-2.88	1.9	16463
	Mar 1994- Mar 2001	0.97	-0.02 (0.3)	0.48 (19.6)	0.99 (224.7)		-2.98	2.0	26085
	Mar 2001- Mar 2008	0.98	-0.05 (0.4)	0.59 (24.6)	0.99 (273.6)		-2.76	2.1	38748
	Mar 2003- Mar 2008	0.98	-0.02 (0.1)	0.55 (18.6)	0.99 (219.4)		-2.87	2.2	25222
Eurozone	Jan 1999- Mar 2008	0.96	-0.05 (1.8)	0.30 (19.3)	0.97 (185.9)		-3.39	2.0	30703
	Jan 1999- Mar 2003	0.97	-0.09 (2.0)	0.44 (16.4)	0.96 (114.1)		-2.97	1.9	15499
	Mar 2003- Mar 2008	0.95	0.00 (0.03)	0.17 (10.5)	0.97 (139.8)		-4.06	2.0	12982.7

Note: The equation used is 2.16. IT stands for inflation targeting.

Source: Bloomberg

The problem with these estimations is that the R^2-value cannot be used to analyse the goodness of fit of the model. It is inflated by the lagged regressor, hence this method cannot be used to eliminate the autocorrelation problem. It can, however, be remedied by using the first difference of both the dependent and independent variables i.e. $\Delta y_t = \beta_2 \Delta x_t + \varepsilon_t$

$$\Delta(ff_{t+90} - ff)_t = \alpha + \beta_1[\Delta(f_t - ff_t)] + \varepsilon_t \qquad (2.17)$$

Table 2.4 Estimating how well interest rate futures predict the policy interest rate by using 1st Difference estimations

Country	Time Period	R^2	α	β_1	β_2 Dummy	t-stat	SIC	Std. Err.	F-Stat
UK	Mar 1988- Mar 2008	0.05	0.00	0.22		16.08	-1.87	0.013	259
1992	Mar 1988-Mar 1992	0.11	0.00	0.27		10.76	-1.24	0.03	116
	Mar 1992- Jun 1997	0.003	-0.00	0.07		1.96	-1.19	0.04	3.8
	Jun 1997- Mar 2008	0.13	0.00	0.31		20.36	-3.44	0.02	415
IT Dummy	Mar 1988- Mar 2008	0.05	0.00	0.22	-0.00	-0.19 (d)	-1.87	0.00 (d)	129
Independence Dummy	Mar 1988- Mar 2008	0.05	0.00	0.22	0.00	0.03 (d)	-1.87	0.00 (d)	129
New Zealand	Jun 1991- Mar 2008	0.42	-0.00	0.90		54.41	-0.24	0.02	2960
	Jun 1991- Jun 1995	0.44	-0.00	0.92		26.73	0.81	0.03	714
1989	Jun 1995- Jun 2001	0.41	-0.00	0.88		31.5	-0.28	0.03	992
	Jun 2001- Mar 2008	0.18	-0.00	0.43		17.6	-3.52	0.02	310
Jun 1991- Mar 2008 excl. Jun 1997- Mar 1999		0.42	0.00	0.88		50.5	-0.37	0.02	2555
Canada	Jun 1993- Mar 2008	0.19	-0.00	0.35		28.9	-2.28	0.01	836
1991	Jun 1993- Dec 1998	0.19	0.00	0.34		17.6	-1.65	0.02	309
	Dec 1998- Dec 2002	0.22	0.00	0.42		16.6	-2.59	0.03	274
	Dec 2002- Mar 2008	0.14	-0.00	0.32		14.6	-3.53	0.02	215
Australia	Jun 1989- Mar 2008	0.31	-0.00	0.56		46.5	-1.95	0.01	2165
1993	Jun 1989- Mar 1993	0.43	-0.00	0.70		26.8	-0.76	0.03	720
	Mar 1993- Mar 1998	0.08	0.00	0.24		10.3	-2.28	0.02	105
	Mar 1998- Mar 2008	0.11	0.00	0.24		17.65	-3.77	0.01	312
IT dummy	Jun 1989- Mar 2008	0.31	-0.00	0.56	0.00	0.41	-1.95	0.00	1082
Sweden	Dec 1992- Dec 2007	0.15	0.00	0.25		15.72	-3.11	0.01	662
1993	Dec 1992- Dec 1997	0.14	0.00	0.21		14.28	-2.66	0.01	204
	Dec 1997- Dec 2002	0.12	-0.00	0.26		13.33	-3.56	0.02	178
	Dec 2002- Dec 2007	0.28	0.00	0.56		22.00	-3.44	0.03	484
Japan	Sep 1989- Mar 2007	0.21	0.00	0.44		34.23	-3.34	0.01	1172
	Sep 1989- Sep 1993	0.20	-0.00	0.44		16.02	-2.13	0.03	257
	Sep 1993- Sep 1997	0.29	0.00	0.56		20.03	-3.60	0.03	401
	Sep 1997- Sep 2002	0.03	0.00	0.08		6.59	-6.51	0.01	44
	Sep 2002- Mar 2007	0.36	0.00	0.66		25.01	-5.48	0.03	626
U.S.	Mar 1989- Mar 2008	0.22	-0.00	0.52		36.6	-2.86	0.01	1338
Mar 1994- Mar 2008 excl. Sep 2001- Sep 2002		0.24	-0.00	0.55		31.7	-2.85	0.02	1007
	Mar 1989- Mar 1994	0.14	-0.00	0.42		14.67	-2.88	0.03	215
	Mar 1994- Mar 2001	0.18	-0.00	0.47		19.6	-2.96	0.02	385
	Mar 2001- Mar 2008	0.30	0.00	0.62		27.11	-2.75	0.02	735
	Mar 2003- Mar 2008	0.28	-0.00	0.60		22.58	-2.87	0.03	510

Country	Time Period	R^2	α	β_1	β_2 Dummy	t-stat	SIC	Std. Err.	F-Stat
Eurozone	Jan 1999- Mar 2008	0.57	-0.12	0.62		14.95	-0.93	0.04	3065
	Jan 1999- Mar 2003	0.65	-0.13	0.70		16.95	-0.61	0.04	1954
	Mar 2003- Mar 2008	0.36	-0.06	0.41		6.27	-1.45	0.07	729

Note: The equation used is 2.17. IT stands for inflation targeting.

Source: Bloomberg

Keeping in mind that financial statistics is volatile and it is usually hard to find "high" R^2-values when using it in regression, the results will be analysed country by country below.

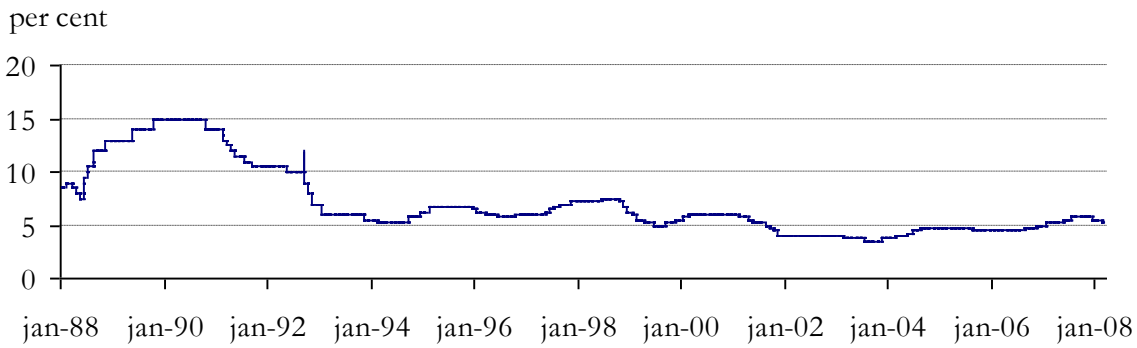
UK

The results in Tables 2.1 and 2.4 both deliver R^2-values that are the highest during the time period June 1997 to March 2008 and the Schwarz information criterion (SIC)[20] confirms the findings. During this period the coefficient of the interest rate future is the highest and most significant and so is also the F-statistics. It seems that the British interest rate futures are most successful in predicting the future interest rate during this period. However, the R^2 is low. The Bank of England introduced inflation targeting in 1992, but did not achieve independence from the Government until 1997. However the Bank of England had already begun to enhance transparency in 1992 by introducing the inflation report. During this time the inflation report included alternative scenarios for the future inflation. This might have caused confusion when trying to forecast the future interest rate. If the inflation target is not explicitly set it is difficult to know how the central bank will react and on which criterion it bases its interest rate decisions. This might explain the extremely low R^2 for the period March 1992 to June 1997 to some extent. Since 1997 the inflation target has been defined in an explicit manner and the number of pages of the inflation report has increased from 45 to 65. The efforts to become more transparent continued after 1997. In 1998 the minutes from the monetary policy meetings were published only 2 weeks after the meetings, before October 1998 this would have taken up to 5 weeks. The minutes include information on how the MPC members have voted, their individual views, and speeches. The dummies for independence of the Bank of England and the introduction of inflation targeting are both insignificant in the regression without autocorrelation in the residuals. Hence, there is no change in the relationship between the interest rate futures and the interest rate at the points in time when the Bank became independent and inflation targeting was implemented. The critical question is why the second largest R^2 can be found before 1992. Maybe the market was better at predicting the future interest rate when they were used to the old system of a

[20] The Schwarz information criterion (also called Bayesian information criterion) is an index that shows the goodness of fit of econometric models. It is based on the maximised log-likelihood method and imposes a penalty for the number of parameters included in the model. It is commonly used for selecting among econometric models.

non-transparent central bank. Another explanation could be that the interest rate stayed at 15 per cent for a rather long period of time. As mentioned before, Swansson (2001) found that a volatile interest rate is harder to predict than a steady.

Figure 2.2 The policy interest rate in the UK 1988 - March 2008



Source: Bloomberg

During the last 10 years the interest rate has by comparison been very stable, maybe it is the reason for the good forecast ability of the interest rate futures in the UK.

New Zealand

New Zealand introduced inflation targeting already in 1989 and the interest rate futures started to trade in 1991. Therefore, it is impossible to measure whether the predictability of interest rate futures on the interest rate has changed after the introduction of inflation targeting. However, as Lasaosa (2005) argues, it might take some time for the market to adjust to the new monetary policy system. Lange et al. (2003) and Swanson (2005) also find a gradual improvement in the predictability of the federal funds rate in the 1990's when the Federal Reserve Bank became more transparent. The conclusion of Lang et al. and Swanson therefore makes it interesting to test how the predictability of the interest rate has developed over the time after inflation targeting was adopted. In the table above (table 2.4) it seems to be the case that interest rate futures can predict up to 44 per cent of the variation in the official interest rate three months later in New Zealand. However the predictability has varied somewhat over the test period. During the time period June 2001 to March 2008 the interest rate futures were hardly able to predict the interest rate; the R^2-value sank to 18 per cent. And one might wonder why the R^2-value is lower in the period 1995 to 2001 compared to the time period before 1995? The reason could be changing monetary policy strategies that probably had an effect on the predictability and credibility of the actions undertaken by the Reserve Bank of New Zealand.

From June 1997 to March 1999 the Reserve Bank of New Zealand used a monetary conditions index (MCI) as an instrument and indicator for its monetary policy. It is a combination of the 90-day change in real/nominal interest rate and the real/nominal exchange rate weighted by 0.5 (this can vary but was 0.5 in New Zealand). It was used to measure the state of monetary policy i.e. how well the monetary policy controlled inflation. However, it caused the interest rate to automatically increase as the exchange rate depreciated. So, when New Zealand experienced negative shocks to the economy, such as the major drought in 1997 and the Asian crisis in 1998, the interest rate increased. An increasing interest rate during these negative shocks was probably not the best remedy, thus it shows that the MCI as an indicator for monetary policy was…"*a significant deviation from best international practice*." (Svensson, 2001, p.3). During Svenssons review of the monetary policy system in New Zealand he found that the MCI had caused unnecessary variability in the interest rate, output and exchange rate. Engelbrecht and Loomes (2002) found that the Australian economy performed better than the New Zealand economy in a study where they compare the two countries over this period of time. Australia did not use the MCI as an operational monetary policy strategy. The Reserve Bank of New Zealand finally abandoned the MCI in March 1999, in favour of the Official Cash Rate (i.e. the policy interest rate) (Svensson, 2001).

Due to the experiences in New Zealand the regression has been carried out again and the observations from June 1997 to March 1999 were excluded. The resulting R^2-value is 0.33 which is quite similar to the R^2-value in the period 1991-1995. In the period June 2001 to March 2008 the R^2-value was almost as low as during the 1995 to 2001 which might be explained by an additional policy change. In 2002 the inflation target was changed from being measured by the CPI over the coming 12 months and allowed to vary between 0 and 3 per cent it was now allowed to vary between 1 and 3 per cent on average over the "medium term". The change from 12 month to the "medium term" gives the central bank more time and flexibility when responding to new data or shocks that pushes inflation outside of the target (Reserve Bank of New Zealand, 2004).

Overall it seems that the interest rate futures were best at predicting the interest rate set by the Reserve Bank of New Zealand during the years right after inflation targeting was implemented, this is also where the lowest SIC value can be found.

Canada

Canada introduced inflation targeting in 1991 and Canadian interest rate futures started to trade in 1992 and it is possible to find continuous data from 1993 and onwards. Therefore, it is just as in the case of New Zealand, not possible to compare the interest rate futures ability to forecast the interest rate before and after inflation targeting was introduced. However, the test will be carried out for the years 1993 to 2007 to check for changes in the interest rate predictability of the private sector. It seems that during the first years after inflation targeting was implemented the interest rate future

was predicting the official interest rate fairly well, the R^2-value is 0.19 which means that only 19 per cent of the changes in the official interest rate were predicted by the private sector. Over the next time period the R^2-value improves and reaches 22 per cent. However, comparing 1993 to 1998 with 1998 to 2002 it is clear that the F-stat and SIC have worsened. From December 2002 to March 2008 the R^2 and F-stat deteriorate and the SIC value increases. Tests were carried out to check whether it has to do with the time period right before Bear Sterns went bankrupt. Deciding exactly when the financial crisis started can be discussed. Some might say that it already started in the summer of 2007, while this study assumes that the starting point for the financial crisis was when Bear Stern's filed for bankruptcy in March 2008. Regression (2.17) is therefore run with observations from the time period December 2002 to June 2007 to see if the regression result improves. The R^2 improves and reaches a value of 0.17 while the SIC-value decreases to -3.63. These improvements are not large which implies that the explanation for the low predictability must lie somewhere else. By following the reasoning that a more varying interest rate is harder to predict the variance of the interest rate in the different time periods is compared in Table 2.5.

Table 2.5 Variance of the Canadian interest rate

Variance of the interest rate	
1.71	June 1993 - December 1998
1.48	December 1998 - December 2002
0.69	December 2002 - March 2008

Source: Bloomberg

The reason for the poor predictability cannot be explained by high variance of the interest rate. In the table above we see that the interest rate was most stable in the last time period. The Bank of Canada (2006a) reports that the introduction of inflation targeting has brought about all the benefits that an inflation targeting regime is supposed to achieve i.e. low inflation, stable interest rates and economic stability and growth. Why has the predictability of the interest rate decreased during the last 6 years? The Canadian economy has been hit by a number of shocks during the years 2001 to 2006 e.g. the collapse of the IT-bubble, the September 11th attacks, corporate scandals, SARS and a rapid increase in oil prices. The Canadian dollar started to appreciate in 2003 mainly due to growing demand and therefore higher prices of natural resources and other commodities that Canada produces. According to the Bank of Canada (2006a) the adjustment to these shocks was difficult. The Canadian monetary policy uses MCI as an operational target for monetary policy in the same way as New Zealand did during 1997-1999. As explained in the part on New Zealand MCI is based not only on the interest rate but also on the real exchange rate. Therefore, an appreciating exchange rate will suggest that the interest rate should be lowered and a depreciating exchange rate will lead to a higher interest rate in Canada. This seems to have been what the Bank of Canada has done, hence the MCI strategy does not explain the poor predictability. The deviation from the inflation target was,

however, larger during these years than the average deviation over the whole period. It can be the case that the increasing deviations in combination with the economic shocks caused problems for the financial market to predict the policy moves by the Bank of Canada and their interest rate decisions.

Australia

Australia implemented inflation targeting in 1993. During the whole time period the predictability is 31 per cent and in the last two time periods it falls to around 10 per cent. The highest R^2-value is found in the period before inflation targeting was introduced. The F-statistics and SIC both support this result. At the end of the 1980's Australian economists were concerned about the inflation level that had averaged around 9 per cent since the start of the 1970's. In combination with a major economic recession during the end of the 1980s a discussion regarding the future monetary policy developed. Inspired by its neighbouring country New Zealand as well as Canada that were conducting major monetary policy changes by implementing inflation targeting, Australian economists decided that inflation targeting was an attractive option (Gruen and Stevens, 2000). Glen Stevens, who has been the Governor of the Reserve Bank of Australia since 2006 says that it was difficult to convince people that the Reserve Bank of Australia was really pursuing inflation targeting at the start (Stevens 1999). The Reserve Bank of Australia did not announce a major change of strategy when it started to pursue inflation targeting. The Reserve Bank Act from 1959 was not rewritten and there was no other formal agreement between the Bank and the Government, pronouncing that inflation targeting should be implemented.

"We just started to say we wanted to keep inflation at around 2-3 per cent, and went about doing it, in a necessarily gradual fashion, I think many observers were looking for more radical redesign" (Stevens 1999, p. 4).

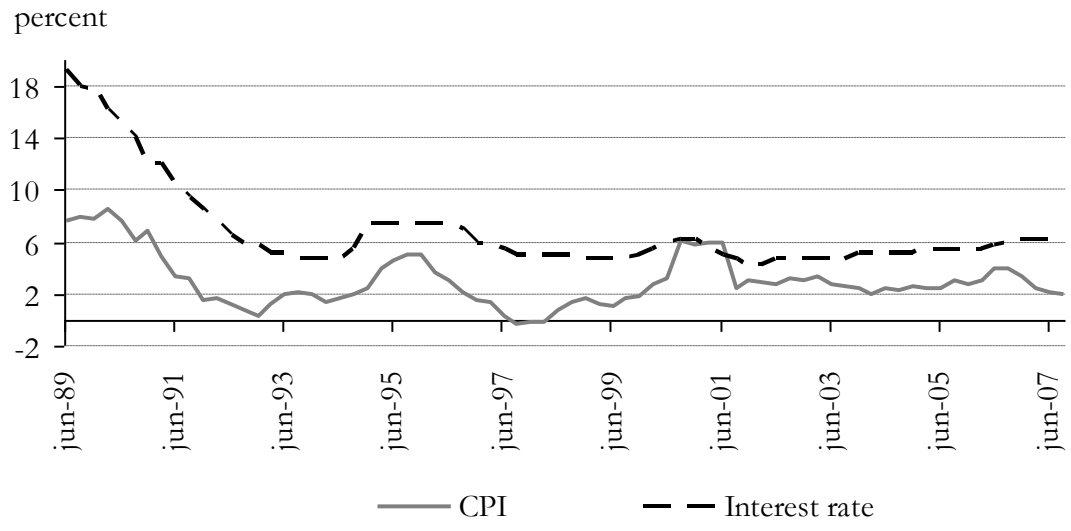
Other inflation targeting countries introduced inflation targeting in a more prominent and precise way. Stevens (2003) says that the Reserve Bank of Australia thought it would be too demanding to target a lower inflation rate than 2-3 per cent on average over a business cycle. Even though many inflation targeting countries have a target at 2 per cent with a tolerance range of +/- 1 per cent over a period of 12 months the Reserve Bank of Australia decided to set the range of inflation target somewhat higher and to control inflation over a longer time period because it assumed it would be too hard to control inflation more precisely than that.

Transparency and communication to the public also developed gradually over time in Australia. In 1992 the Reserve Bank started to publish a quarterly report on the economy. This report contained 4 to 5 pages, 5 years later the report contained more than 50 pages. Since 1996 the Reserve Bank of Australia has published its inflation report quarterly and the Governor has begun to communicate more with the public. These arrangements have led to a more transparent central bank that has gained more and more credibility over a long period of time. Hence, in the Australian data it will

probably be difficult to find distinct cuts or changes in the regression statistics. An inflation targeting dummy has been added to the regression in order to test this. The dummy is, however, not significant even at the 90 per cent level. This gives the result that there is no significant change in the predictability of the future interest rate before and after inflation targeting was implemented. Before 1993 the model delivers a R^2-value of 0.43. The high R^2-value might be explained by the fact that the Reserve Bank of Australia began to enhance transparency already in 1990 by announcing its operational target for the cash rate when the monetary policy changed (Battelino, Broadbend and Lowe, 1997).

Since inflation targeting was gradually accepted by the public the regression carried out using 3 sub-groups of the data in order to estimate the development over time. 1993 to 1998 the predictability is very low, R^2-value reaches only 8 per cent, the F-stat and SIC deteriorate as well. After 1998 the R^2-value improves slightly to 11 per cent. A dummy for the years when inflation targeting was in place is added to the last regression for Australia. The dummy is not significant, hence the introduction of inflation targeting has not had an effect on the interest rate expectations in Australia. Let us start by looking at how inflation and the interest rate have developed since 1989. Growth of CPI measures the inflation level for the whole period even though the Reserve Bank used the underlying CPI to measure the inflation level until 1998.

Figure 2.3 Australia's inflation and interest rate 1989-2007



Source: Bloomberg

The interest rate decreases as inflation comes down from almost 8 per cent in 1989 to nearly zero per cent in 1992. As inflation increases the interest rate is held constant at around 5 per cent. The Reserve Bank of Australia then lets inflation reach more than 5 per cent in 1995. The interest rate is increased to 7 per cent but it seems that the Reserve Bank was not able to foresee and hinder the

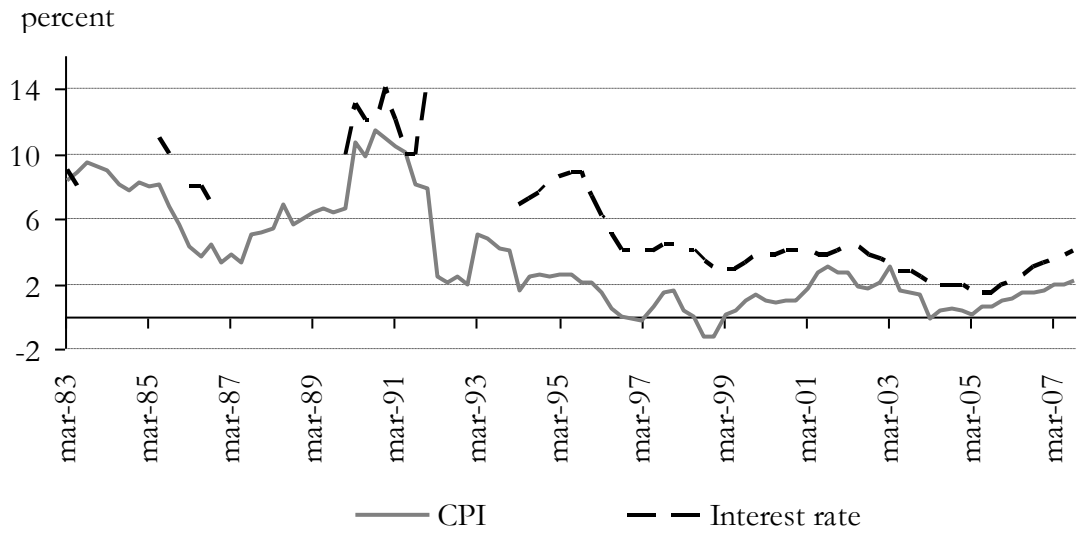
quick increase in prices. Inflation reached levels of 6 per cent in the 3rd quarter of 2000 and the Reserve Bank even lowered the interest rate in the second quarter of 2001 when inflation was still at 6 per cent. It seems that the prices vary extremely quickly in Australia. One explanation for the reserve bank letting prices grow by 6 per cent is that it intends to keep inflation at a level of 2 to 3 per cent over a business cycle and thereby seems to have a more relaxed view on increasing prices in the short run. When comparing the R^2-value with the rest of the countries in this study it is clear that Australia has the second lowest predictability of its future interest rate (after the UK). In the speech by Stevens (2003) he mentions that a significant proportion of the households in Australia still anticipate inflation at 10 per cent or more.

Sweden

Sweden introduced inflation targeting in January 1993. At that time Sweden had experienced what the Swedes call "the happy 1980's" which was financed by an ever rising inflation level under a fixed exchange rate. This finally resulted in a financial collapse and dramatic devaluation of the Swedish krona when the Riksbank no longer was able to defend the fixed exchange rate in November 1992. Just as New Zealand and many other countries, Sweden chose to focus on a stable and low inflation rate and a flexible exchange rate for its future monetary policy in order to avoid future problems with time-inconsistency[21], the Riksbank was separated from the government and gained independence at the end of 1992. Over the whole period, 1992 to 2007, the regression result produces a R^2-value of 0.15. During the years 1993 to 1997 the predictability of the future interest rate is only 14 per cent. Looking at the figure below, it seems that it took the Swedes some years to lower their expectations for the future inflation rate. Figure 2.4, shows the inflation rate measured by CPI. The inflation rate did come down to its target level in 1994 but the average interest rate between 1993 and 1997 was 7 per cent which means that monetary policy was tight.

[21] The time-inconsistency problem arises when expansionary monetary policy is conducted. In the short-run expansionary monetary policy is able to lower unemployment rates and produce higher growth. However, in the long-run it does not achieve economic growth or decreasing unemployment. In other words it does not have any real effects; the only thing gained is high inflation (Mishkin, 1999).

Figure 2.4 Sweden's inflation and interest rate 1983-2007



Source: Bloomberg

One reason for the tight monetary policy found by Giavazzi and Mishkin (2006) was the uncertainty about what would happen to the exchange rate if the interest rate was lowered. The exchange rate was an important indicator for the interest rate decisions until 1996 when its importance decreased and the Riksbank started to present inflation forecasts with probability distributions. This led to decreased inflation expectations and the bank gained confidence and trustworthiness. Giavazzi and Mishkin find that the Riksbank succeeded in stabilising inflation expectations by keeping interest rates relatively high until the bank was sure that low inflation expectations had been well anchored before the executive board decided to decrease the interest rate. After 1997 the interest rate was decreased and between 1998 and 2002 it has varied around 3.7 per cent. However, the R^2-value falls to an even lower level during 1997 to 2002, which implies that the predictability of the Riksbank worsened. In 1999 a new central bank act was implemented. This meant that the Riksbank increased its independence and was allowed to appoint independent members of the policy committee that cannot be replaced during long-run mandate periods.

Forecasting the future inflation rate can be very difficult and the following example shows how the board of directors at the Riksbank underestimated the future inflation rated. In June 2001 the Riksbank decreased the policy interest rate by 25 basis points, probably due to the fact that inflation had only increased by 1 per cent over the first half of 2001. However, the second half of 2001 surprised by a quick rise in inflation (3 per cent). Hence, the Riksbank did not only underestimate the future inflation rate it also changed its interpretation of the prevailing economic data and indicators.

Giavazzi and Mishkin (2006) find signs that the executive board changed its interpretation and focus on economic data. For example, at the end of 2003 the house price development in Sweden started to

play a more prominent role in the discussions at the policy meetings. The executive board worried that lowered interest rate would give the already surging house prices a further boost. Since 2003 the importance of house prices has steadily increased, which has led to tighter monetary policy. One can speculate about whether this was the reason for the relatively high interest rate observed in 2003 or if the Riksbank simply misjudged the future inflation. It seems that the Riksbank was able to keep inflation low but its strategy kept changing over time and this probably created uncertainty about future interest rate decisions.

In the last time period the predictability of the interest rate improves and reaches 28 per cent. This result is confirmed by the F-statistics. Looking at figure 2.4, it is clear that the interest rate moved less during these years and that inflation stayed low, well below its target of 2 per cent. Both variables are less volatile than during the previous years. However, as inflation increased during the last quarter of 2005 and onwards, the interest rate was raised in a similar manner. The analysis of Sweden shows that not only did the market participants have to learn how the Riksbank acts, also the board of directors had to decide how to practically pursue inflation targeting.

Comparing the influence the central banks themselves think they have on expectations in the private sector

It is also interesting to compare the predictability found through the tests in this chapter with how Central Banks themselves answer when being asked what influence their publications and statements have on private expectations[22]. The Bank of England answers that "it depends", whether the Central Bank's projections for the inflation rate in their report, affect private expectations. The result from the regression analysis in the UK show that the private expectations do not predict the interest rate particularly well when using interest rate futures as a proxy for private expectations. The Reserve Bank of Australia answers that the inflation report and its projections in the report have a significant effect on private expectations and that the inflation report has a high impact on the analysis of private sector forecasters. This claim does not seem to be confirmed by observing the interest rate futures predictability on the future interest rate in this study. The Riksbank and the Reserve Bank of New Zealand on the other hand say that the reports have no significant effect. In Sweden this seems to be right, but from the results for New Zealand one can argue the opposite, since the interest rate futures predict the future interest rate rather well. The Bank of Canada has unfortunately not answered the question and from the results it seems that the private sector is quite poor at predicting the future interest rate in Canada, however the result is still a bit better than in Sweden.

[22] See appendix 1, table 2.

The three final countries and regions that were tested are the U.S., Japan and the Eurozone. These countries are not pure inflation targeting countries and will be used as a reference group.

U.S.

As explained in the introduction the Federal Reserve Bank in the U.S. started to focus on keeping a low inflation level in the early 1980's. In the 1990's the Federal Reserve increased its transparency by announcing monetary policy decisions and release press statements right after the end of the meetings. According to Sardoni and Randall Wray (2006) a highly transparent monetary policy is a key principle for the Fed's policy formation. The Federal Reserve has, furthermore, announced that it intends to keep inflation low, while it will not lose its focus on output. Therefore the Federal Reserve does not conduct inflation targeting with at numerical range or explicit target.

Looking at the regression result of how well the 1-month fed funds futures predict the future fed rate, it is clear that the relationship is rather strong. This is probably a result of using 1-month futures instead of 3-month interest rate futures which were used in the other countries. The R^2-value and t-statistics are fairly high over the whole period. There seems to be a change in the R^2-value between the two first time periods and the two last ones. The Federal Reserve increased transparency in 1994 by announcing the set interest rate target. Lang et al. (2003) also find that their R^2-value improves after 1994 (1994-2000) compared to the time period previous to 1994 (1989-1994)[23]. When excluding the effects by the attacks on the World trade center in September 2001 by one year the R^2-value improves to 0.24. During the last time period, March 2001 to March 2008 it reaches 0.3 i.e. 30 per cent of the variation can be foreseen in the variation of the interest rate future. This is a fairly large figure compared to the inflation targeting countries, especially compared to Australia and the UK. It shows that the transparency of the Federal Reserve Bank's monetary policy has enhanced predictability of the future interest rate even though it does not pursue explicit inflation targeting.

Japan

The overall result for Japan is similar to the one in the U.S., except from 2002 to 2007 when the R^2-value is very low. This might be explained by the Asian currency crisis in 1997 to 1998 and the Japanese banking crisis in 1997. Japan struggled with low growth and deflation even before the Asian crisis. In the second part of the 1990's the deflation in prices made the economy shrink. From 1997 to 2002 the nominal Japanese GDP decreased by 4 per cent (Takatoshi, 2004). The Bank of Japan achieved independence from the government in April 1998. Five years later the growth rate of the economy reached 3 per cent and the inflation rate finally increased. Takatoshi (2004) further

[23] Lang et al. (2001) and Swanson (2004) estimates basically the same regression model as this study does. However they use monthly averages which results in significantly higher R-squares than those found here.

explains that the reasons for not introducing inflation targeting was that Japan was experiencing deflation and no inflation targeting country had experienced that when implementing the inflation targeting strategy. Most inflation targeting countries implemented inflation targeting as a mean to reduce inflation- not to increase it. However, in October 2003 the Bank of Japan decided to enhance transparency in the sense that it was to provide a more detailed description of its policy and evaluation of the economic development e.g. the development in prices. The efforts to increase transparency have continued over the years. Therefore it is likely that the increased transparency in combination with a recovering economy and financial system are reflected in the improved R^2-value that reaches 0.36 during September 2002 to March 2007. Compared to Sweden this is higher for almost the same time period.

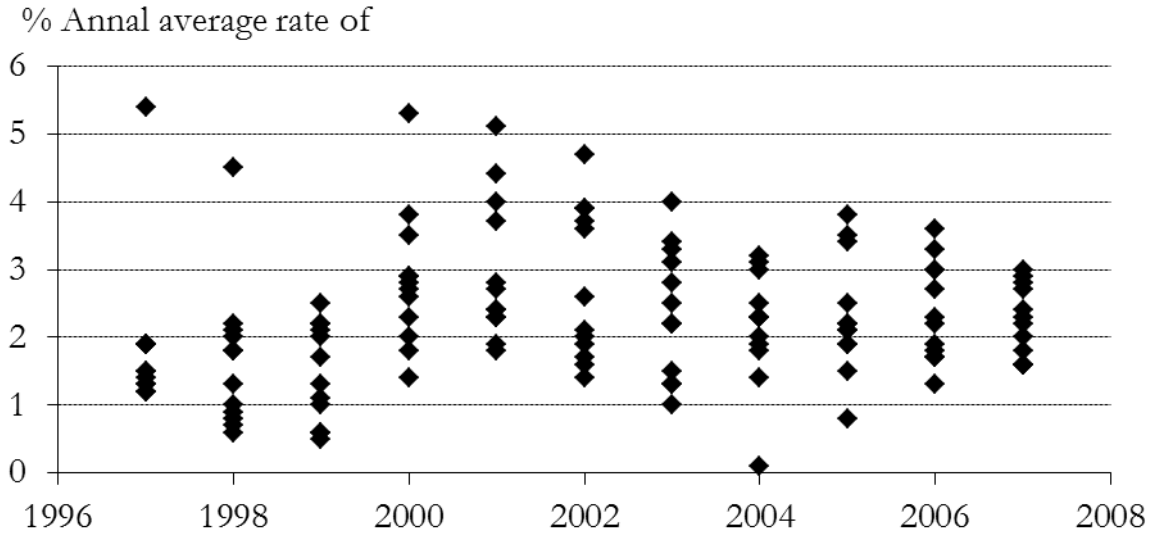
Eurozone

Looking at the ability of the Eurozone's interest rate futures to predict the future interest rate it is clear that the futures have predicted the interest rate very well during 1999 to 2003. It is the highest R^2-values in this study. The low SIC and high F-statistics confirms this. However, the R^2-value, SIC and F-statistics deteriorate in the last time period. This might be explained by the ECB's monetary policy strategy. Its primary objective is to maintain price stability. It does so by using two "pillars". The first pillar focuses on the growth rate of the money stock (M3). The reference rate of the M3 growth rate was set to 4.5 per cent by the ECB since the start of the EMU (Walton and Daly 2003). Pillar number two assesses the future inflation development. As Belke et al. (2003) describe it, the strategy is a mix of monetary targeting and inflation targeting. Monetary targeting was a strategy pursued by the Deutsche Bundesbank in the 1980's and 1990's. By using these two pillars the ECB's main objective is to keep prices stable, measured by Harmonised Index of Consumer Prices (HICP), at "close to below 2 per cent" (Walton and Daly 2003). During the first years (i.e. 1999 to 2003) the market seemed to understand the ECB's objective and forecasted the interest rate rather well. During the second period the R^2-value drops considerably in the empirical test above. This might have to do with the changes or lack of changes that the ECB introduced after its and the national central banks' reviews were conducted in the spring of 2003. The ECB decided not to make any major changes in its monetary policy strategy in May 2003. However, the price stability objective was rephrased and would from now on be defined as "below but close to 2 per cent" and the importance of the growth of M3 was reduced. Svensson (2003), Walton and Daly (2003), and de Gruawe (2003) agree with the ECB, that reducing the importance of the M3 growth rate was a step in the right direction. According to de Grauwe, M3 is a variable that holds much "white noise" and can therefore give misleading signals regarding the stability of prices. He uses the turmoil after the September 11th attacks as an example. Directly after the attacks, investors fled to short-term assets. By doing so they increased M3 significantly. Hence the growth of M3 occurred due to nervous investors and not increased prices. Had the ECB not taken these circumstances into account for its future interest rate decisions it could

have led to a tightening monetary policy with a possible deflationary effect. Concerning the second pillar, all four economists (among others) dispute the target definition "below but close to 2 per cent". They suggest that it does not provide the market with more clarity nor transparency and is still in need of further improvement. Svensson (2003) argues that it is difficult to tell what "close to 2 per cent" exactly means. Why not just set a target to e.g. 1.8 per cent? Or does close to 2 mean 1 to 2 per cent? de Grauwe (2003) proposes that the ECB should switch to more explicit inflation targeting in order to help the market understand the policy actions of the central bank and make the bank more transparent. While, Wallet and Daly (2003) suggest that a symmetric inflation target of 2 per cent +/-1 would be preferable in order to anchor inflation expectations and furthermore guard against deflation.

An additional explanation for the low R^2 value from 2003 to 2008 might be that the inflation level in the Eurozone has varied considerably among the countries. In 2003 for example, Spain's inflation level reached 3.1 per cent, Ireland 4 per cent while the Netherlands and Germany had an inflation rate of 1.4 and 1 per cent respectively. With this variation it must be difficult for the participants on the private market to foresee what interest rate decisions the ECB will make. In this context it is not surprising that the predictability decreased over the last time period. However, looking at the figure below it seems that the inflation rates have converged over the last three years and this does not help explain the sinking R^2. A more plausible explanation is probably ECB's lack of an explicit target which seems to confuse the private sector.

Figure 2.5 The HICP average annual change in the different Eurozone countries



Source: Eurostat

2.4.3 DETECTING STRUCTURAL BREAKS

So called stability models or tests of structural change can be helpful when trying to find structural breaks. A structural break is found when the regression coefficients vary significantly among different subsets in the data. This can be due to a regime change; in this case it would be when the central bank introduced inflation targeting. One of the most common tests is the Chow breakpoint test[24]. This test allows the coefficients to be different over the chosen time periods, in matrix form:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta 2 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{2.18}$$

Y and **X** are divided into $\mathbf{y_1}$ and $\mathbf{X_1}$ i.e. representing data before the change, while $\mathbf{y_2}$ and $\mathbf{X_2}$ contain data after the change. Equation 2.18 is an unrestricted regression. The Chow breakpoint test compares the sum of squared residuals found in the unrestricted and restricted regression.

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \beta + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{2.19}$$

The regression does not allow the coefficients to vary throughout the different time periods. The estimated values of the coefficient β_1 (i.e. the relationship between the interest rate future and the future interest rate) in table 2.1, varies over the different time periods tested for each country. It seems likely that one will find many breakpoints in the time series. The Chow breakpoint test is based on prior information regarding when the structural change has occurred (Greene, 2003). In appendix 2, the result of Chow breakpoint test for the different time periods is presented. The first test controls whether a break has occurred for each year. In all countries there seems to have occurred a structural break every year. A structural break is featured by F-statistics that exceeds its critical value and in this investigation they all exceed this value, which means that there are statistically significant breaks at all tested points in time. The figures in appendix 2 present the development of the F-statistics over time. The following analysis is based on these figures and the coefficients, $\beta_{1,}$ found in the different countries and time periods. It seems that the inflation targeting countries have experienced large structural breaks especially at the start of the implementation of the new policy strategy.

[24] This test is an application of the F-test.

UK

Looking closer at the results in the UK data it is clear that the most significant structural breaks are found through the years 1993 to 1995. Over the following years significant structural breaks continues to occur every year but they become less and less significant. The very significant breaks at the beginning of the time period may be the result of the adjustment process after the inflation targeting introduction and the Bank's steps to achieve credibility and transparency. The pattern of decreasing F-statistics can be seen in Australia, Japan and Canada as well and could be the result of the adjustment process of increased transparency and inflation targeting.

Australia

The structural breaks in Australia can be found throughout all the years after the introduction of inflation targeting. Since the Reserve Bank of Australia introduced inflation targeting in a step by step manner it is not a surprising result. The significance of the breaks presented in appendix 2 become less and less significant over time, even though they are all still statistically significant. This indicates an improvement in the stability of the estimator although it remains quite unstable.

Canada

Canada gives a result that resembles that of Australia. Canada experiences the most significant break in 1998 according to the figure in appendix 2, thereafter the breaks become less and less significant. There is a second peak in 2001 which can be explained by the economic difficulties that Canada went through (see the previous section). The breaks decrease continuously until 2008 which implies that the estimator gained stability over time. Despite this, the policy interest rate forecasts worsened after 2003. Hence the increasingly stable estimator did not seem to help the private sector to make better interest rate forecasts.

New Zealand

The breaks in New Zealand are relatively small in the first half of the 1990's but increase and reach a peak around 1997. This might be a result of the introduction of the MCI in 1997 and the negative economic shocks that New Zealand experienced during 1997 and 1998. The breaks become less and less significant after 2000 but do not decrease further as can be seen in most of the other countries. This result is confirmed by the regression result in table 2.4. It is difficult to find an explanation for this. However, the Reserve Bank of New Zealand changed its monetary policy objective in 2002 into a more implicit target that loosened its objective somewhat compared to what is was before. This has made the estimator slightly more volatile over time but has had a considerable worsening effect on the predictability of the future policy rate decisions made by the Reserve Bank (see table 2.4).

Sweden

The breaks in Sweden do not resemble the pattern in the countries above. Overall the breaks are more significant in Sweden than in the rest of the inflation targeting countries. Exceptionally large breaks occurred between 1993 and 1997 as well as between 2000 and 2002. The large breaks in 1993 to 1997 can be explained by the adjustment to inflation targeting while the breaks in 2000 to 2002 may be a result of the turbulence on the stock market and the sluggish economic growth during these years. In the years after 2003 Sweden seems to continuously encounter major structural breaks which might have to do with the way monetary policy was conducted. As explained in the previous section the Riksbank started to let house prices influence the interest rate decisions in 2003. On one occasion the interest rate was raised in order to slow down the rapidly increasing house prices even though the inflation rate was decreasing (Riksbank, 2006). The significant breaks might be explained the somewhat varying objectives of the Riksbank that had destabilising effects on the expected interest rate. However, the ability for the private sector to forecast the policy interest rate during 2003 to 2007 was the best compared to the previous time periods. This implies that the Riksbank's communication and transparency helped the market to better foresee the future interest rate.

Japan

The breaks in Japan are larger than in any of the other countries[25] over the whole period. However the breaks decrease and follow a pattern similar to the UK, Canada, and Australia. The highly significant breaks can be a consequence of the economic turbulence Japan experienced in the 1990's. The significance of the breaks decreases remarkably in 1999 and continues to shrink until 2007. It seems that the estimator becomes increasingly stable after 1999 and the result in table 2.4 shows that the market became better at predicting the future interest rate after 2002 as well.

U.S.

The breaks between 1996 and 2001 are very small compared to the other countries but still statistically significant. The significance of the breaks increase in 2002 which may be explained by the enhanced transparency of the Federal Reserve's monetary policy that also improved the predictability of private market's interest rate forecasts (see table 2.4). However, the significance of the breaks begins to increase in 2002 which suggests that the estimator became more volatile between 2002 and 2007. Even though the estimator was very volatile over time the private market was able to predict the future interest rate most successfully in this time period. Hence, the transparency and communication of the Federal Reserve helped the market to understand and foresee the interest rate decisions of the FOMC despite the volatile estimator.

[25] Please, observe that the scale on the Y-axis is much larger than in the other figures.

Eurozone

The estimated estimator in the Eurozone experiences larger and larger breaks as time moves on. In addition, the predictability of the interest rate decisions decrease considerably (see the result of the R^2-value in table 2.4). This might be explained by the lack of an explicit objective or other shortcomings in the transparency in ECB's monetary policy which seems to confuse the market.

One setback when using the Chow breakpoint test is that the time of the breakpoint has to be known. If it is not certain when the structural breaks have taken place, the cumulative sum of recursive residuals also called the CUSUM test can be used. It compares the recursive estimates of the regression coefficient with the estimates of the whole sample (Zeileis, Kleiber and Hornik, 2003). The null hypothesis in this test is that the estimated coefficient β_1 is constant over time. The alternative hypothesis is then that the coefficient varies over time. The result of this test can be found in appendix 3. The graphs represent the cumulated sum of the recursive residuals. The area around zero, plus minus 2 standard errors is where the parameter is considered to be stable. Movements outside the 2 standard errors (5 per cent significance) indicate parameter instability at the 95 per cent level e.g. structural breaks that have caused the parameter to change its value.

The CUSUM test shows that there has been great parameter instability in all of the countries. For Sweden the coefficient was relatively stable during the years 1996 to 2000. UK, Canada and Japan have coefficients that are very unstable while New Zealand has time periods characterised by stable coefficients. One of them is during 1999 to 2002 right after MCI was abandoned and New Zealand was recovering from an economic slowdown. Australia also reveals a couple of years, 1995 to 1999, when the coefficients were stable. The graph presenting the CUSUM test in the U.S. almost has an identical time period when the coefficients were stable at the 95 per cent level. In countries with inflation targeting the coefficient for the variable interest rate future does not stay stable. This represents shifts, which in some cases may be the result of policy changes. Others seem to be inconsistent over the entire test period. The results from these structural breaks tests show that they occur almost every year in the countries. In what way and how well the interest rate futures predict the future interest rate change every year and even the breaks seem to become less and less significant. However, they are still significant at the 99 per cent level in almost all countries and each year.

2.4.4 How well have the inflation targeting countries achieved their inflation targets?

By comparing the result above with the result found by Gosselin (2005), Albagli and Schmidt-Hebbel (2004) it is possible to analyse the credibility of the central bank. Gosselin, Albagli and Schmidt-Hebbel compare how well the inflation targeting countries have attained their inflation targets.

Logically one would think that if the central banks are able to achieve the set inflation target very well, then their credibility would improve. The actors on the financial markets would trust the central bank to perfectly predict the future inflation and set an interest rate that achieves that inflation target, hence there would be positive correlation between small deviations from the target and good predictability of the interest rate. Gosselin, Albagli and Schmidt-Hebbel investigate the inflation level, starting when the countries introduced inflation targeting until 2005 and 2004 respectively. Gosselin finds that Sweden for instance has a tendency of undershooting its target while the UK has a history of over shooting its target. By simply calculating the average quarterly deviation of the inflation target a result it is possible to compare the private sectors' predictability with the credibility of the central banks. The quarterly growth rate of the consumer price index that many countries use to measure inflation[26] represents the inflation.

Table 2.6 How inflation has deviated from the countries' inflation targets

Country	Time period	Average deviation from IT	Average deviation in absolute numbers
UK	Q1 1992 to Q3 2007	-0.05	0.67
New Zealand	Q1 1990 to Q3 2007	0.32	1.08
Canada	Q1 1991 to Q3 2007	-0.09	0.69
Australia	Q1 1993 to Q3 2007	0.10	1.06
Sweden	Q1 1993 to Q3 2007	-0.53	1.12

Note: IT stands for inflation target.

Source: Bloomberg

The analysis of the deviation from the inflation target in table 2.6 above, shows that the Bank of England has been most successful at keep the inflation level close to its target compared to the other countries. It has been undershooting slightly and the average deviation in absolute numbers is the smallest. From this result one would think that the financial market would be able to predict the interest rate best in the UK. However, the empirical result in this study (table 2.4) does not confirm this reasoning in the case of the UK. Nevertheless, the empirical result in table 2.4 can help explain the poor predictability in Sweden. The interest rate futures do a poor job at forecasting the policy interest rate in Sweden and this might be explained by the great average deviation of the inflation level compared to the inflation target, both in nominal and absolute terms. In New Zealand where the private sector could best foresee the future interest rate (44 per cent), the deviations have almost been as large as in Sweden. The difference of predictability of the interest rate might be explained by better communication and more transparent policy decisions in the central banks of Sweden and New Zealand.

[26] E.g. Sweden and Canada.

2.5 RESULTS

This chapter has found that the financial market participants in the inflation targeting countries have not been able to improve their forecasting ability to predict the future interest rate significantly after inflation targeting was introduced. On average New Zealand is the only country where one can claim that the private sector can predict some of the variation of the future interest rate. In addition, New Zealand has been, after Sweden, the country that has deviated most from its inflation target since it was introduced in 1989. This might indicate a small success of the central bank's transparency and communication in New Zealand. Since the private sector has been able to forecast the interest rate the best among the inflation targeters despite large deviations from its inflation target. New Zealand is furthermore the country that seems to run the most "hard core" inflation targeting strategy among the countries in this study (see the results in the next chapter).

The countries where the private sector is best at predicting the future policy interest rate are the ones without an explicit inflation target, i.e. Japan, U.S. and the Eurozone in this study. However, all three countries have central banks that have improved transparency. This implies that an explicit inflation target does not help the financial market to understand central bank policy decisions. Controlling inflation and setting the "correct" interest rate is probably just as Macklem (2002, p. 1) argues:

"While the objective is simple, achieving it is not straightforward. Inflation control is complicated by several factors: it is very indirect, it is not totally precise, and it takes a long time"

Inflation is hard to control and central banks, themselves, will often misjudge the future inflation and thereby set the "wrong" interest rate. However, this reasoning would not affect the markets' expectations of the interest rate since their information about the current economy is not too different from the central banks' since no one can predict the future. What seems to be a problem is that the central banks often change its strategy as well as how they interpret different indicators under inflation targeting; hence operational and information transparency problems. For example in Canada the exchange rate plays a role in the interest rate decisions while in Sweden house prices became an increasingly important indicator for future inflation in 2003. This will naturally confuse the market participants and their ability to forecast the actions of the central banks.

3 MEASURING THE INFLATION AND NON-INFLATION TARGETING COUNTRIES BEHAVIOUR USING THE TAYLOR RULE

3.1 INTRODUCTION AND PURPOSE

This chapter intends to estimate how well the central banks have been following the Taylor rule and to estimate how large the weights on controlling output and inflation have been. If a country's central bank claims to pursue inflation targeting one would expect the weight put on keeping inflation close to its target to be larger than the weight put on closing the output gap (Svensson, 1999, see section 2.2.3). The empirical analysis in this chapter tests whether this reasoning holds in the inflation targeting countries. It also assesses if the results differ in the inflation targeting countries and the non-inflation targeting countries. The countries studied are the same as in the previous chapter, hence the inflation targeters are: UK, Canada, Australia, New Zealand and Sweden, while the non-inflation targeting countries are U.S., Japan and the Eurozone.

The first part of this chapter compares the policy interest rate set by the central banks with the interest rate that the Taylor rule would suggest using Taylor's original equation with equal weights on inflation and output. The second part of the chapter estimates the size of the weights that have actually been employed in order to control inflation and output by using the econometric procedure: General Methods of Moments. The analysis of the results includes an overview of the consumer price index development in the inflation targeting and non-inflation targeting countries.

3.2 PREVIOUS RESEARCH

Many studies have been conducted in order to test the Taylor rule for different countries and reasons. Countries in the Eurozone (EMU countries) have been thoroughly studied by e.g. Gerlach and Schnabel (1999). They have investigated how well the interest rate in the EMU countries followed the interest rate suggested by the Taylor rule. They found that the interest rate calculated by using Taylor's rule moved closely to the realised interest rates in the countries, considering the prevailing average output gaps and inflation levels using quarterly data over the years 1990 to 1997. Belke and Polleit (2007) have compared how the ECB and the U.S. Federal Reserve Bank set their interest rates. They have used the Taylor rule and data from the period 1999 to 2005 in their study. The results show that the standard Taylor rule is a better tool for modelling the behaviour for the Federal Reserve compared to the ECB. The ECB puts more focus on closing the output gap than on

reaching the inflation target, while the Federal Reserve seems to put equal focus on inflation and the output gap; hence Taylor's original estimation from 1993 holds when using updated time series on U.S. data. Faust, Rogers and Wright (2001) have compared the monetary policy of the German Bundesbank and the ECB by using the Taylor rule. Similar to the observation made by Belke and Polleit (2007), they find that the ECB focuses more on the output gap than on inflation compared to the Bundesbank. The Taylor rule model is also used by Carstensen and Colavecchio (2004) in order to evaluate whether there had been any structural breaks in the ECB monetary policy strategy over the years 1999 to 2004. Even though ECB revised its monetary policy in May 2003, Carsten and Colavecchio could not find that a break had occurred as a consequence of the revision. Judd and Rudebusch (1998) have tested Taylor's rule using data from the U.S. They use the weights 0.5 on both the inflation instrument and output gap and find that these weights describe the Federal Reserve's monetary policy very well, especially during the years 1988 to 1998. This chapter will begin by comparing the actual policy interest rate in the chosen inflation and non-inflation targeting countries with the interest rate that Taylor would have suggested if the countries central bank's had followed the Taylor rule blindly. The result will be presented graphically in the empirical analysis. In the second part of the empirical analysis the weights that the policy makers have put on controlling inflation and the output gap will be estimated econometrically.

3.3 EMPIRICAL ANALYSIS

As explained above the empirical analysis is divided into two parts. The first calculates the interest rate by using Taylor's original equation and assumptions. The results will be presented graphically below and compared with the actual policy interest rate that the central banks have employed. The second part of the empirical analysis econometrically estimates the weight the policy makers have put on keeping inflation at its target and output at its potential level.

3.3.1 EMPIRICAL FRAMEWORK AND DATA SELECTION

The Taylor rule was described theoretically in the previous chapter and will now be used in order to investigate how well the countries follow the rule. The reason for doing this is to get a clear picture of which interest rate the Taylor rule would suggest compared to the policy interest rate that the central banks actually put into practice. This will be done by using the weight 0.5 on both the inflation deviation and output gap, just as Taylor did in 1993. This gives the following equation:

$$i_t = \pi_t + r^* + 0.5(\pi_t - \pi^*) + 0.5\left(\frac{y_t - y_t^*}{y_t^*} * 100\right) \quad (3.1)$$

The inflation rate (π_t) is measured by quarterly data on the countries CPI growth. The equilibrium or target interest rate (r^*) is assumed to be constant over time at 2 per cent. The inflation target (π^*) will be set by the policy of the individual countries, see appendix 1 (Facts and figures on inflation targeting countries), hence for Sweden it will be 2 per cent. In this study it is assumed that the countries without an explicit inflation target (U.S., Eurozone and Japan) use 2 per cent as a policy guideline. The reason for this is that most inflation targeting countries use 2 per cent as a middle value of their explicit target range. For the countries such as the U.S., Taylor (1993) among other economists has found that 2 per cent inflation gives good results when investigating the Federal Reserve's monetary policy. Furthermore the ECB aims at keeping inflation "below but close to 2 per cent over the medium term" (ECB's homepage, 18/8-09). Therefore, the parameter π^* will be set equal to 2 per cent for both inflation targeting and non-inflation targeting countries in the estimations with the exception of Australia which will be set at 2.5 per cent because the Australian inflation target is defined as 2 to 3 per cent. y_t^* is calculated by employing the Hodrick-Prescott filter with the smoothing parameter λ=1600. Realised quarterly GDP is represented by y_t.

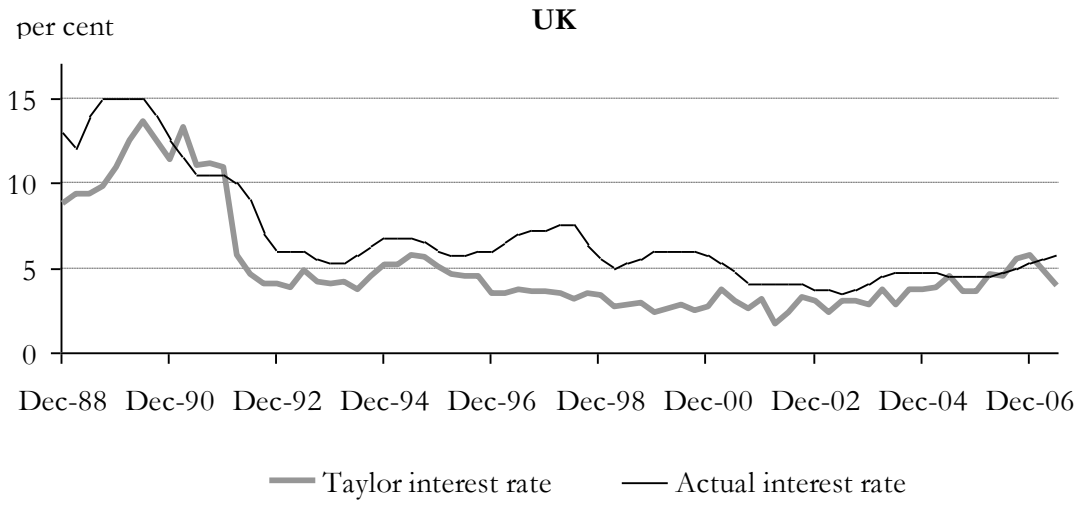
Data selection

The data on GDP is gathered from OECD's data base while data on CPI development and the policy interest rates come from IMF's International Financial Statistics (IFS). The frequency of the data is quarterly and ranges from the end of the 1980's in most countries to the third quarter of 2007.

3.3.2 GRAPHIC PRESENTATION OF THE TAYLOR RULE

The interest rate estimated with the use of the Taylor rule (equation 3.1) will be compared with the actual realised policy interest rate set by the countries' central banks. The result is presented and discussed below.

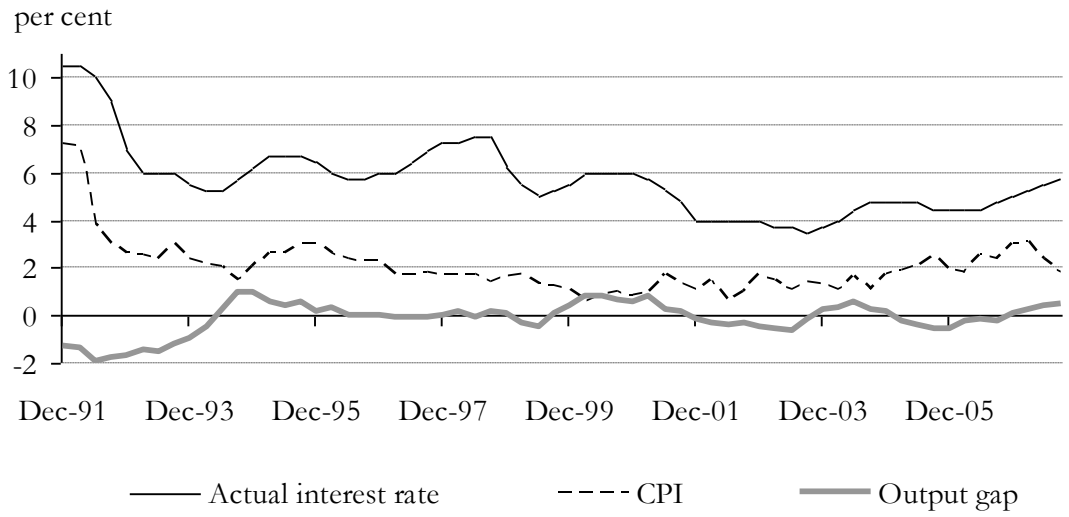
Figure 3.1 Taylor interest rate and actual interest rate in the UK



Source: OECD and IFS

The inflation target in the UK has been set to 2 per cent since 1992. In the graph above one can see that the interest rate calculated with the help of Taylor's rule is lower during almost the whole period compared to the actual interest rate set by the Bank of England. They were very close around the time when inflation targeting was first introduced in 1992. However during the mid-1990's to 2000 the Taylor rule would suggest a significantly lower interest rate. This signals that the Bank of England has put more focus on controlling inflation than the Taylor rule suggests; the Bank of England was running a loose monetary policy. After 2000 and onwards the interest rates converge but the actual interest rate remains higher than Taylor's until 2006. Does this development mean that the Bank of England has allowed for higher levels of inflation or was it able to keep down the inflation due to a credible inflation target which pushed down the inflation expectations? The figure below shows the growth of CPI, the output gap and actual policy interest rate.

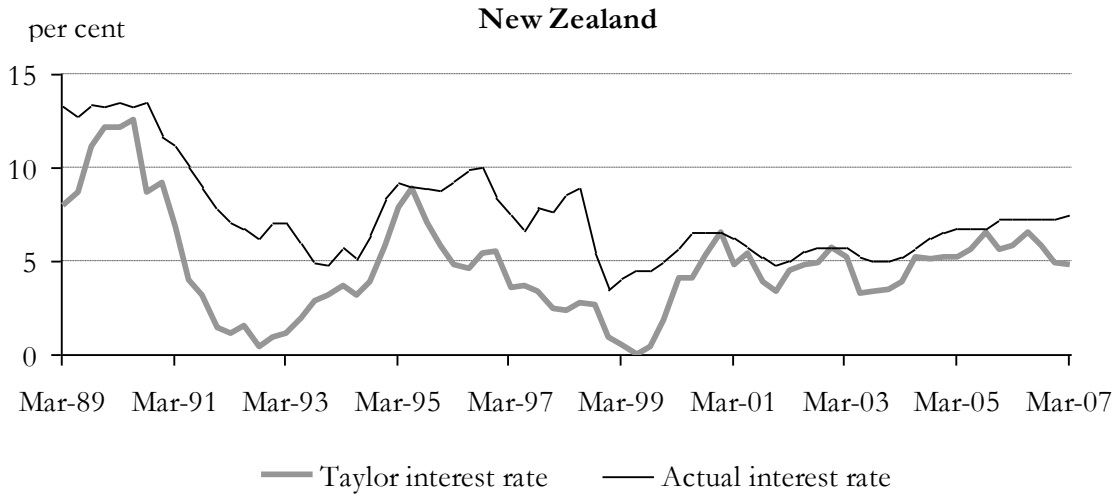
Figure 3.2 Actual interest rate, output gap and CPI growth in the UK



Source: OECD and IFS

The CPI growth has been developing at around 2 per cent over the whole period after 1993 which shows that the Bank of England has managed to keep inflation around its target at most times. It takes 1 to 2 years for the interest rate to have an effect on the inflation level, the sharp rises in the interest rate in March 1998 probably affected CPI growth, at the latest, in March 2000. During 2000, the CPI growth went down to 0.6 per cent in the 2nd quarter; hence the interest rate was too high-looking at it only from the inflation targeting perspective. Maybe the MPCs wanted to tighten monetary policy after they had failed to keep inflation around its target of 2 per cent between 1992 and 1997. It is quite natural that inflation expectations were higher than the inflation target during these years. The Bank of England had not yet showed the private sector that it would succeed in keeping inflation around 2 per cent. In other words, the Bank of England had not yet achieved a credible monetary policy in that it could keep inflation at its target. The UK experienced an average inflation level of 5 per cent between 1988 and 1992. It seems that the Bank of England was forced to lower inflation expectations by keeping the interest rate relatively high at the start of the implementation of inflation targeting. The interest rate was decreased in 2002 and 2003, this soon lead to an increase in the inflation level which reached 2.5 per cent in the 3rd quarter of 2005. The inflation level continued to rise and the Bank of England started a set of interest rate hikes in the last quarter of 2005 that increased the policy interest rate by a whole percentage points in just 3 quarters. However inflation continued to accelerate, which suggests that the interest rate was not raised enough. Taylor's interest rate in figure 3.1 confirms this in that the Taylor interest rate exceeds the actual interest rate. It seems that the Bank of England chose to focus more on promoting output than on controlling inflation.

Figure 3.3 Taylor interest rate and actual interest rate in New Zealand



Source: OECD and IFS

New Zealand has had an inflation target range of 1 to 3 per cent since 1989 and in the above graph the mean 2 is used. The figure shows that the overall actual interest rate has been higher than Taylor would suggest over almost the whole period. This implies that the Reserve Bank of New Zealand has focused mainly on keeping the inflation level at its target. An explanation for the high interest rate during the first years of inflation targeting suggests that the Reserve Bank of New Zealand wanted to achieve a credible inflation target and therefore put extra focus on keeping inflation low. It may also imply that a high interest rate was required to push down inflation expectations after years of double digit inflation growth. The drawing below shows that there was some scepticism about whether the Reserve Bank of New Zealand would be successful in getting down inflation to 0-2 per cent per year when the target was announced in 1990.

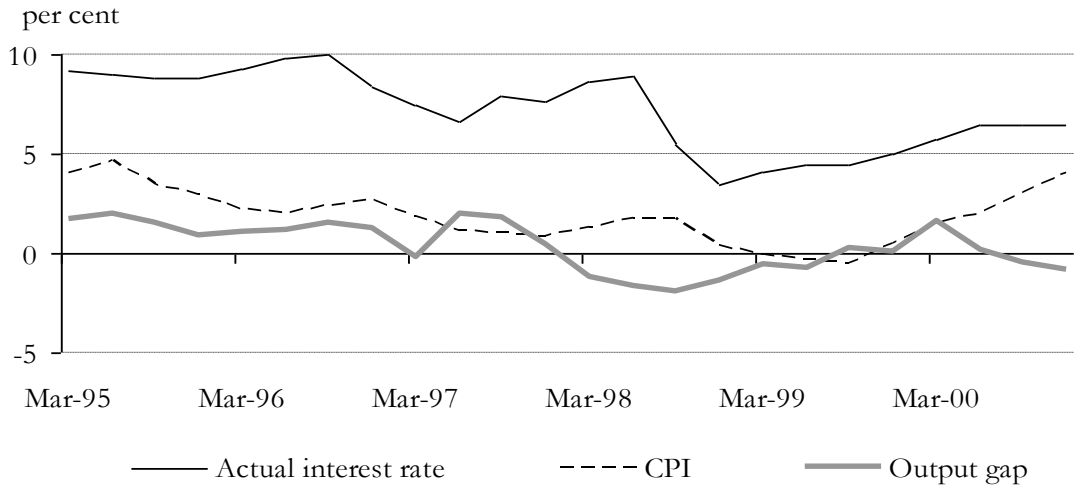
Figure 3.4 Cynicism about the ability to control inflation in New Zealand

Source: Reserve Bank of New Zealand, p.9, 2007

In 1994 the actual interest rate came down to a level close to Taylor's interest rate and even though the actual interest rate stayed somewhat higher it converged towards the levels suggested by Taylor in the second quarter of 1995. In the third quarter of 1995 both interest rates started to diverge and the actual interest rate increased while Taylor's rate would have suggested interest rate cuts to be implemented in a number of steps until June 1999. The Reserve Bank of New Zealand used MCI[27] as an instrument for its monetary policy and this might be the reason for the high interest rate during these years. The value of the New Zealand dollar fell as a consequence of a major drought in the country and due to the Asian crisis which affected the Asian and Oceania economies. Since the Reserve Bank used the MCI instrument this caused the interest rate to automatically increase. Looking at figure 3.5 it is clear that the interest rate was raised at a point in time when the output gap was negative and inflation was below the target of 2 per cent.

The Reserve Bank of New Zealand abandoned the MCI strategy in June 1999 and since then the interest rate has been slightly higher than Taylor's interest rate. However, the fact that the interest rate has been higher than Taylor's interest rate over the whole period on average, gives an indication that more focus has been put on keeping inflation low versus promoting output in order to reach its potential level, especially in the 1990's.

Figure 3.5 Actual interest rate, output gap and CPI growth in New Zealand



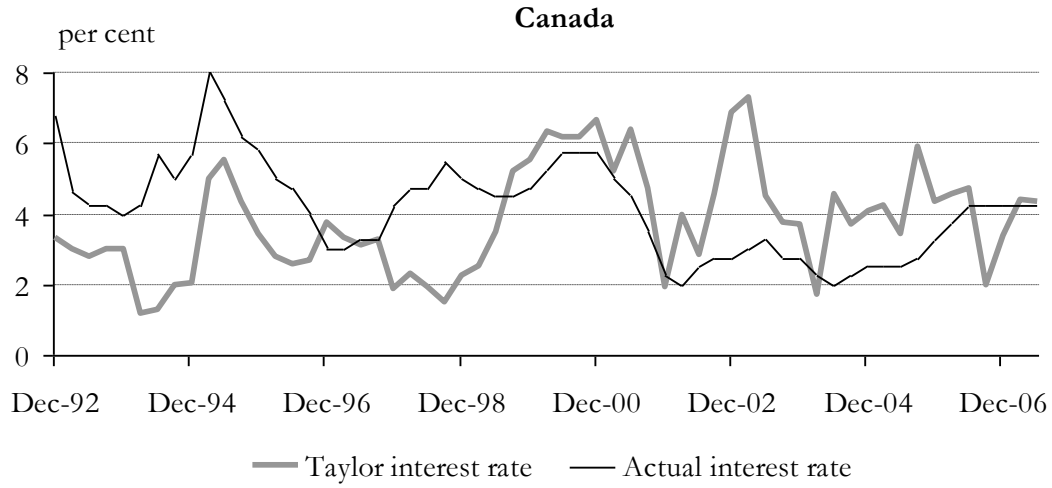
Source: OECD and IFS

After 2000 the interest rates have moved closely together with a smaller difference between the actual and Taylor's interest rate. This can be explained by either that i) the Reserve Bank of New

[27] Monetary Conditions Index (MCI) as an instrument and indicator for its monetary policy. It is a combination of the 90-day change in real/nominal interest rate and the real/nominal exchange rate weighted by 0.5 (this can vary but was 0.5 in New Zealand). It was used by the Reserve Bank of New Zealand to measure the state of monetary policy between March 1997 and June 1999.

Zealand has put less focus on keeping inflation low or ii) that the public has low expectations on the future inflation. The inflation level has on average been higher after 2000, 2.6 per cent, compared to the average inflation rate between 1990 and 2000 that was 2.1 per cent. Can it be that the Reserve Bank has changed its focus on low inflation or did something else happen? As explained in the previous section, the inflation target was revised in 2001. It was changed from "1 to 3 per cent over the next 12 months" to "1 to 3 per cent over the *medium term*". This change will give the Reserve Bank more time to adjust inflation to the target if it is influenced by external shocks and probably allow for a somewhat higher inflation level. The change shows that the Reserve Bank has loosened its inflation target in the short run and it is a possible explanation for the slightly higher inflation level and the lower actual interest rate that moved closer to Taylor's interest rate.

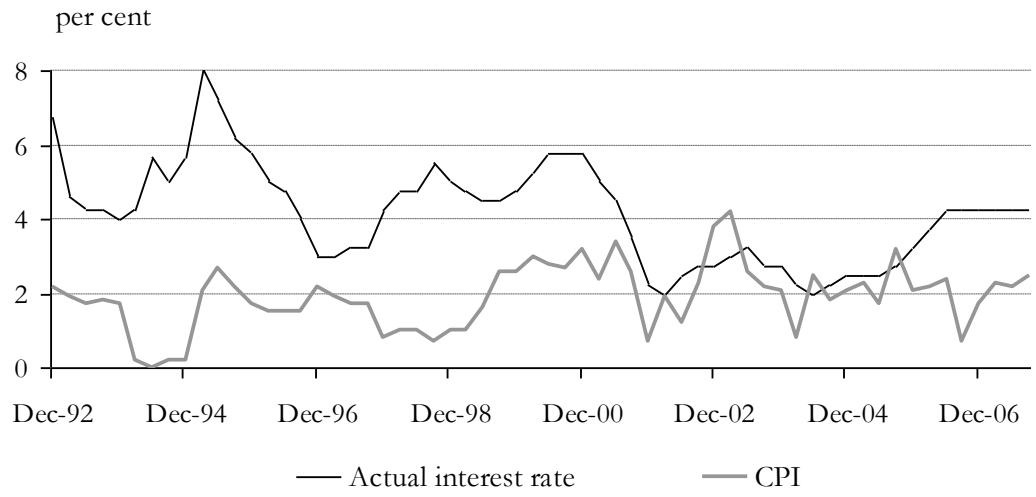
Figure 3.6 Taylor interest rate and actual interest rate in Canada



Source: OECD and IFS

The actual interest rate in Canada exceeded Taylor's interest rate until the third quarter of 1999, with the exception of the winter of 1996-97. This indicates that the Bank of Canada focused more on keeping inflation low than Taylor would have suggested until 1999. Afterwards this changed and the average actual interest rate was lower than Taylor's interest rate until the start of 2006. The Bank of Canada explains that it chose to stimulate the economy by easing monetary policy during these years due to external shocks that had a negative impact on the Canadian economy, e.g. the burst of the high-tech bubble, corporate scandals and September 11th to name a few. In 2006, the Bank of Canada decided to withdraw some of this monetary stimulus by raising the interest rate (Bank of Canada 2006b).

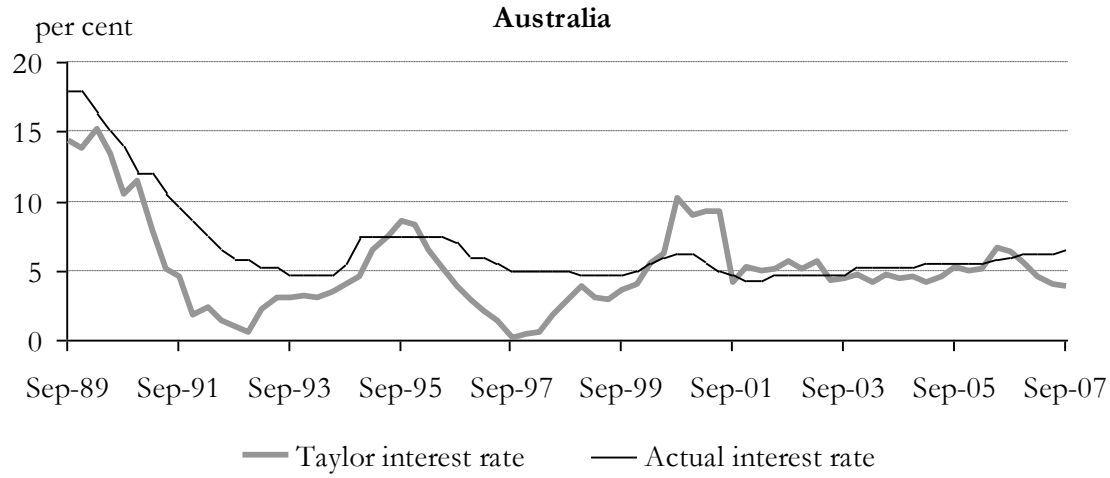
Figure 3.7 Development of the actual interest rate and inflation in Canada



Source: IFS

Above is shown how CPI has developed in Canada over the same period as in figure 3.6. With the exception of 2003 when CPI grew by 4.2 per cent, inflation has grown around 2 per cent which is within the set range of the inflation target of 1-3 per cent. This implies that even though the actual interest rate has been relatively low, inflation has not exceeded its target on more than a couple of occasions.

Figure 3.8 Taylor interest rate and actual interest rate in Australia

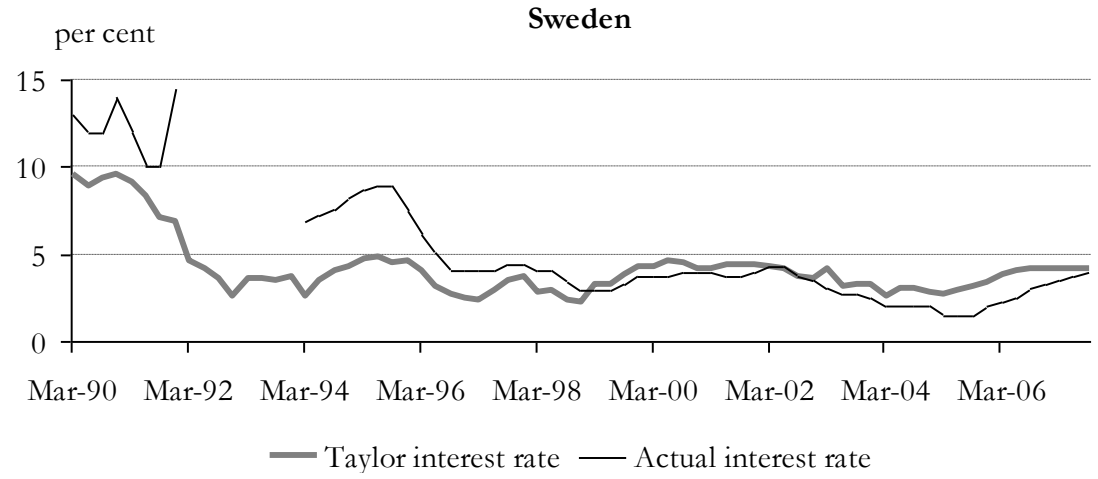


Source: OECD and IFS

In Australia the actual interest rate has been higher than the interest rate suggested by Taylor, over most of the period between 1989 and 2000. After 2001 the interest rates move very close to one another. This implies that the Reserve Bank of Australia has been focusing equally on output and inflation. Nevertheless Australia has been able to keep inflation relatively low since the Reserve Bank

of Australia announced that it would target an inflation rate of 2-3 per cent in 1993. Inflation targeting was introduced more casually in Australia[28] than in the other inflation targeting countries and therefore the close relationship between Taylor's and the actual interest rate is not a surprising result.

Figure 3.9 Taylor interest rate and actual interest rate in Sweden

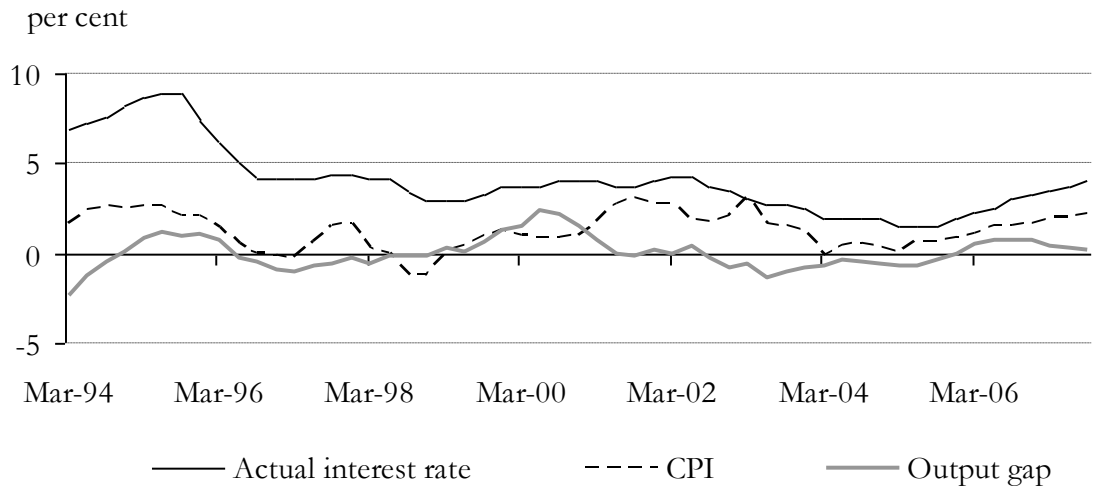


Source: OECD and IFS

There is a break in the time series representing Sweden's actual interest rate. This is due to the financial crisis and the Riksbank's attempt to defend the exchange rate of the Swedish krona. The Riksbank raised the interest rate to triple digit levels in its acute attempts to support the krona. Since the policy interest rate through this time period does not represent "normal circumstances" it is excluded from the time series. Looking at figure 3.9 it is clear that the interest rate was higher than Taylor would suggest during the first seven years after inflation targeting was introduced. In 1999 this changed and the Riksbank followed the Taylor rule closely until March 2004 where the actual interest rate moves father below Taylor's. Hence, the Riksbank seems to have eased its monetary policy after 1999. Figure 3.10 illustrates that the loosened interest rate did not lead to a higher inflation rate. Inflation grew on average by 1 per cent per year between 2004 and 2007.

[28] For further information on how Australia implemented inflation targeting see section 2.4.2 in the previous chapter.

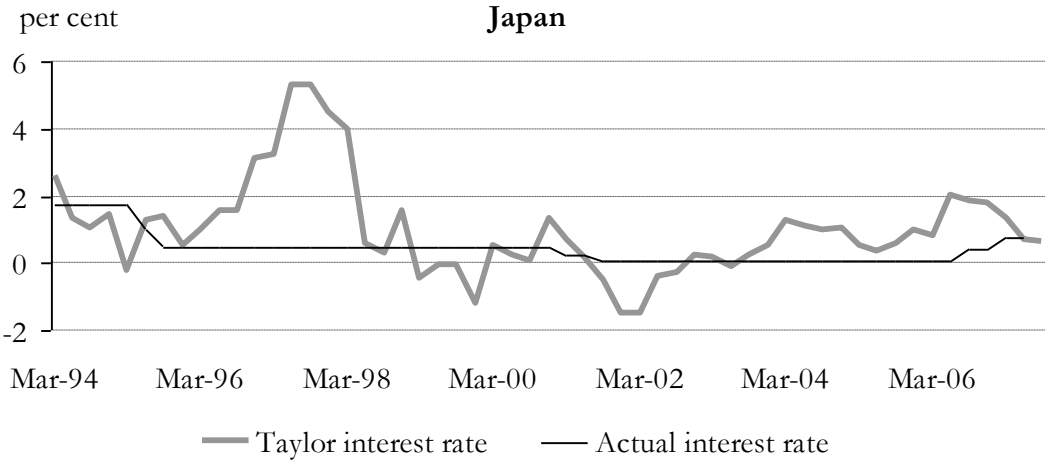
Figure 3.10 Actual interest rate, output gap and CPI in Sweden



Source: OECD and IFS

From this perspective the Riksbank could have set an even lower interest rate during this time period than it did. One reason was that the Riksbank tried to control the rapidly increasing house prices by raising the interest rate, see section 2.4.2 in the previous chapter.

Figure 3.11 Taylor interest rate and actual interest rate in Japan



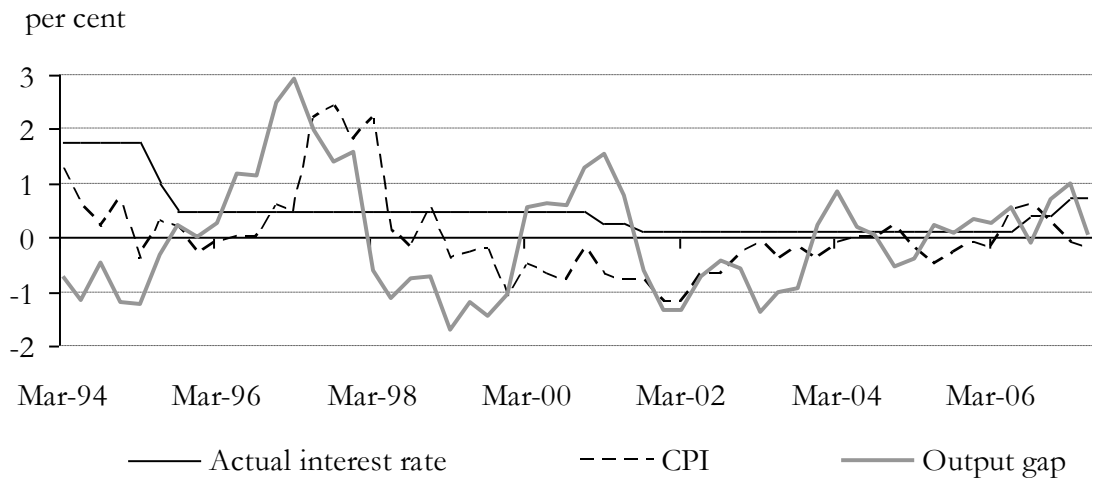
Source: OECD and IFS

Japan is a special case compared to the other countries studied in this thesis[29]. This graph shows that Taylor would have recommended an interest rate of -1.5 per cent in 2002. When calculating the Taylor rule above by applying the same assumptions which have been used for the other countries i.e. the inflation target is 2 per cent and the equilibrium interest rate is 2 per cent. These assumptions

[29] Japan will therefore be excluded from the research in the following section and chapter of this thesis.

may not be suitable for Japan, as its economy went through an unusually long time period characterised by deflation.

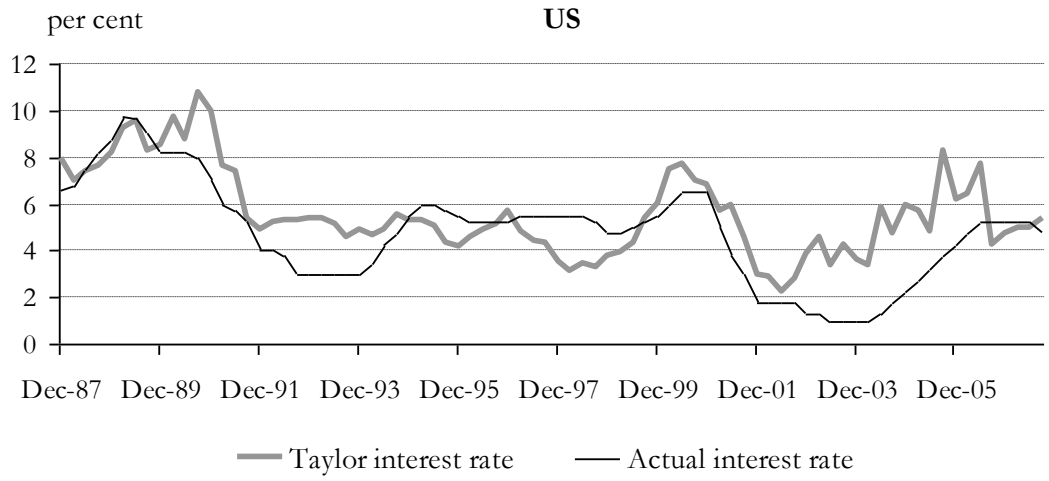
Figure 3.12 Actual interest rate, output gap and CPI growth in Japan



Source: OECD and IFS

The figure above illustrates the time periods of deflation that Japan has experienced, it also presents the volatile output gap. Even though the output gap was positive, which means that the economy grew stronger than at its potential level, between the second quarter of 2000 and the first quarter of 2001, Japan encountered deflation. It is only in 2006 that inflation picks up and the interest rate is carefully raised.

Figure 3.13 Taylor interest rate and actual interest rate in the U.S.

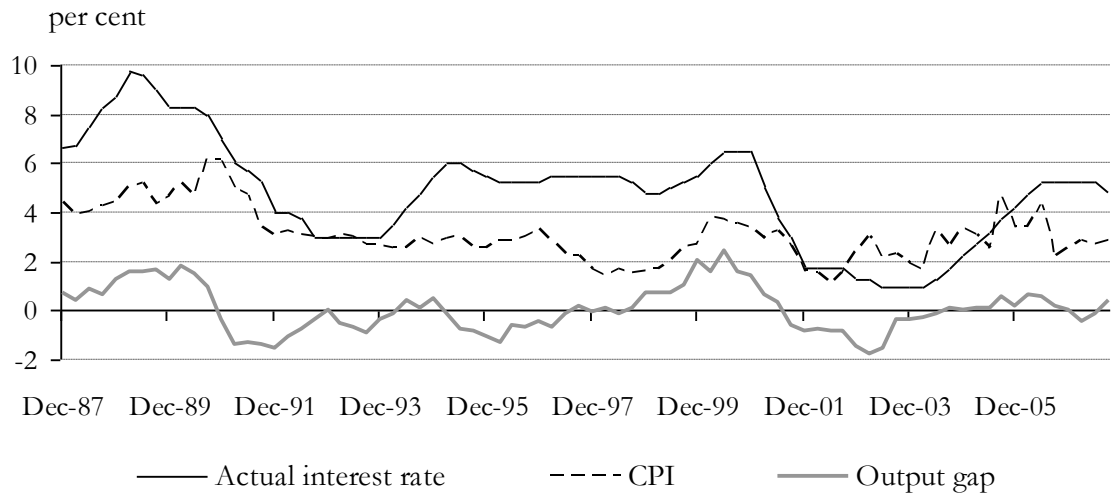


Source: OECD and IFS

From the graph above it is clear that the actual interest rate followed the Taylor interest rate quite closely until 2001. Just as Judd and Rudebusch (1998) found, the figure above shows that the Federal

funds rate moves very similar to Taylor's interest rate during the years when Alan Greenspan was chairman of the Federal Reserve Bank. However, after 2001, while Greenspan was still the chairman of the Federal Reserve, the interest rate was kept at a lower level than Taylor' rule would suggest. Looking back one might argue that the actual interest rate was too low and was a contributing factor to the booming house market. The Federal Reserve was focusing on stimulating growth by setting a very low policy rate during the years 2001 to 2006. By doing so it created an environment where a house price bubble could develop.

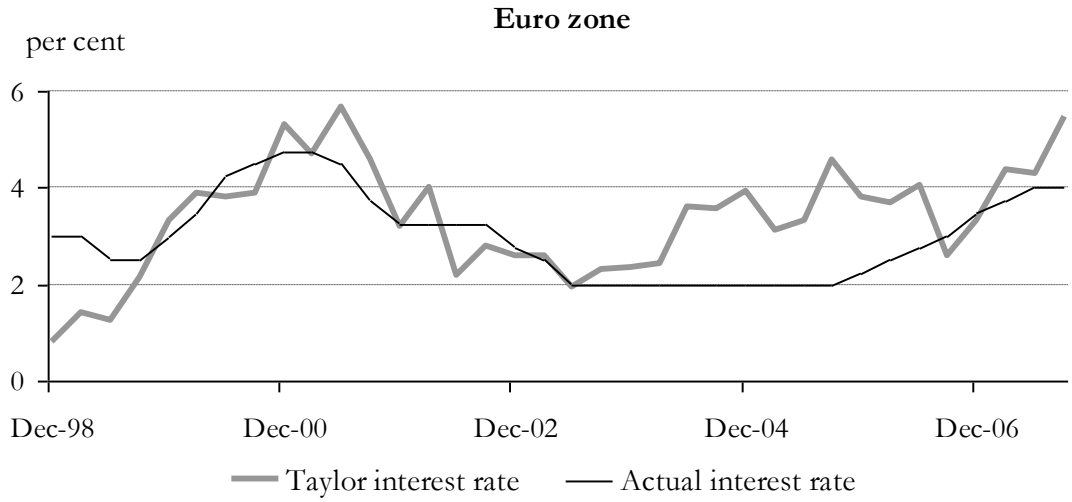
Figure 3.14 Actual interest rate, output gap and CPI growth in the U.S.



Source: OECD and IFS

The inflation rate was kept between 2 to 3.3 per cent between the years 2001 and 2004 which is not alarmingly high. The inflation level of 4.7 per cent was reached in the 3rd quarter of 2005 and by then the interest rate was only 3.75 per cent. The Federal Reserve Bank kept increasing the rate until it reached 5.25 per cent one year later. This is the time when the residential delinquency rate started to increase on real estate loans and it has continued to increase until Q2 2010 (Federal Reserve Statistical Release, March 2011).

Figure 3.15 Taylor interest rate and actual interest rate in the Eurozone



Source: OECD and IFS

In the Eurozone, Taylor's and the actual interest rate move in line with each other until 2003 which suggests that the ECB was focusing equally much on promoting GDP growth as keeping inflation around 2 per cent. However, in the first quarter of 2003 Taylor's interest rate starts to increase while the actual interest rate is kept at 2 per cent until the third quarter of 2005. One can assume that the ECB was focusing more on stimulating the economy than on controlling inflation during this period. Comparing the figure above with figure 3.13 that represents the policy rate in the U.S. they have similarities in that both central banks have held on to a policy rate that was much lower than what Taylor would have suggested, hence they were both stimulating their economies by easing monetary policy. This implies that the ECB has been focusing more on output growth than on controlling inflation since 2003.

The calculations above are based on Taylor's assumption that equal weight is put on controlling inflation and output. If a central bank's only concern is to keep the inflation level close to its target then one would expect it to put all its focus on controlling inflation. Then the Taylor equation would look like this.

$$i_t = \pi_t + r^* + 1(\pi_t - \pi^*) + 0\left(\frac{y_t - y_t^*}{y_t^*} * 100\right) \qquad (3.2)$$

However, in reality the inflation targeting countries are no "inflation targeting nutters" i.e. their central banks main objective is to keep inflation at its target but they shall also create an environment that enables stable economic growth. As observed in the graphic presentation above, the Taylor rule with weights of 0.5 follows the set policy interest rate fairly well in most inflation targeting countries. This implies that the countries are focusing on output and the inflation target.

Schmidt-Hebbel and Tapia (2002) have also found that inflation targeting central banks use inflation and output gap as arguments in their objective function; hence they do not only consider inflation in their policy decisions. The purpose of the next section is to test how much weight the different central banks have put on controlling inflation and output.

3.3.3 Econometric estimation of the Taylor Rule

This section assesses the weights central banks utilize to keep inflation at its target and to minimise the output gap. The purpose is to test whether the weights differ between inflation targeting countries and non-inflation targeting countries. The following equation will be tested.

$$i_t = r^* + \pi_t + \beta_1(\pi_t - \pi^*) + \beta_2\left(\frac{y_t - y_t^*}{y_t^*} * 100\right) + \varepsilon_t \quad (3.3)$$

By rearranging and letting: $\beta_0 = r^* + \pi^*$ and $\tilde{y}_t = \left(\frac{y_t - y_t^*}{y_t^*} * 100\right)$ (3.4)

Equation 3.3 can be rewritten and expressed in the following manner:

$$i_t = \beta_0 + (1 + \beta_1)(\pi_t - \pi^*) + \beta_2\tilde{y}_t + \varepsilon_t \quad (3.5)$$

According to the "Taylor Principle" (Taylor, 1998) the weight put on inflation (β_1) should be larger than one and the weight put on closing the output gap (β_2) should be larger than zero in order for monetary policy to control inflation and output. Clarida et al. (2000) argue that if the interest rule gives a β_1 that is not larger than one then the interest rule has a destabilising effect on inflation. This means that the central bank does not control inflation by increasing the interest rate sufficiently. The focus put on output stabilisation (β_2), has a less restrictive condition, the condition is that it has to be positive. Woodford (2001) explains that if β_2 is positive the interest rate will decrease when the output gap is negative and thereby stimulate economic growth. On the other hand, if the economy is growing above its potential i.e. the output gap is positive the interest rate will increase and thus cool off the economy.

Central banks tend to move the policy interest rate in small steps, by either raising or lowering the interest rate with respect to its current level. If the central bank's intention is to increase the policy rate it does this by raising the interest rate in a number of steps at the policy meetings. This is called interest rate smoothing and is done in order to avoid shocking the financial markets. Economist Gerlach and Schnabel (1999) and Clarida et al. (2000) have shown that an interest rate smoothing

parameter helps to explain the mechanism that describes the target interest rate i_t*. The realised interest rate, i_t, adjusts to this target and to the previous interest rate according to the following equation

$$i_t = \rho(i_{t-1}) + (1-\rho)i_t \quad (3.6)$$

where ρ is the smoothing parameter. This leads to the following reaction function:

$$i_t = \rho(i_{t-1}) + (1-\rho)(\alpha + \beta_1\pi_t + \beta_2\tilde{y}_t + \varepsilon_t) \quad (3.7)$$

The equation above will be estimated by GMM. The GMM approach is basically an instrumental variables estimation. When the exogeneity condition $E(X_i'u_i) = 0$ is violated one has to use the instrumental variables procedure (Wooldridge, 2002). GMM is a modern approach to instrument variables estimation and is widely used in econometric modelling of time series data with independent sample observations. It utilises a theoretical relationship that the parameters are assumed to satisfy, then it chooses estimates that minimise the weighted distance between the theoretical values and the actual value (Hamilton, 1994). The method is often used to estimate interest rate decisions because at the time when these are made the policy committee members can only observe the *ex post* realised right hand side variables i.e. inflation, output and the current interest rate. It is a robust estimator that is not sensitive to heteroskedasticity or serial correlation (Carstensen and Colavecchio, 2004).

The variables, output gap and inflation, will be lagged by 2 years (8 lags) and 1 year (4 lags) respectively. In order to test whether the instrument variables (i.e. the interest rate, future inflation rate and the output gap) have a joint effect on the interest rate decisions, a simple OLS regressions will be performed for each country. The F-statistics show whether the instruments have a joint statistically significant effect on the interest rate. The null hypothesis assumes that β_1 and β_2 equal zero.

$$Interest\ rate_t = \alpha + \beta_1(cpi_{t-1} - 2) + \beta_2(output\ gap_{t-2}) + \varepsilon_t \quad (3.8)$$

Data selection

The data used in this estimation is the same as above i.e. GDP-data is gathered from OECD's data base while data on CPI development and the policy interest rates stem from IMF's IFS database. The frequency of the data is quarterly and ranges from the end of the 1980's in most countries to the third quarter of 2007, the exact time periods are presented in table 3.1, below.

Table 3.1 Testing the joint significance of the variables in the Taylor equation

Country	Sample period	R^2	F-stats	α	β_1 (inflation)	β_2 (output)	Obser.
UK	1989Q1-2007Q3	0.61	53.1*	5.53 (36.8)	0.75 (9.4)	0.20 (0.1)	69
New Zealand	1988Q1-2007Q3	0.36	20.3*	6.70 (31.0)	0.81 (5.9)	-0.09 (0.6)	71
Canada	1992Q4-2007Q3	0.50	26.5*	3.93 (28.8)	-0.42 (2.7)	-0.76 (5.3)	52
Australia	1989Q2-2007Q3	0.21	9.50*	5.73 (41.9)	0.21 (2.1)	0.24 (1.7)	66
Sweden	1983Q1-2007Q3	0.71	87.4*	4.7 (20.3)	0.97 (13.2)	-0.44 (2.6)	71
Japan	1994Q1-2007Q3	0.20	6.6*	0.61 (7.1)	0.13 (3.4)	-0.01 (0.3)	47
U.S.	1988Q1-2007Q3	0.11	5.6*	3.7 (12.5)	0.69 (3.3)	-0.23 (0.95)	72
Eurozone	1998Q4-2007Q3	0.11	2.8*	3.01 (15.3)	0.43 (1.4)	-0.36 (1.8)	28

*) The F-statistics show that the null hypothesis can be rejected in the estimations for each country at the 99 per cent level, hence the chosen variables are jointly significant.
Note: The t-statistics of the slope coefficients (also called estimators in the analysis) are given in the parenthesises below the coefficients.
Source: OECD and IFS

Table 3.1 shows that the slope coefficients are statistically significant not equal to zero and the null hypothesis can be rejected; hence the variables are relevant when estimating the reaction function 3.7, which includes the smoothing parameter.

Table 3.2 Estimation of the Taylor equation

Country	R^2	ρ (smooth)	α	β_1 (inflation)	β_2 (output)	J-stat	Observ.
UK							
1993- 2007	0.85	1.03 (23.0)	1.22 (8.29)	0.11 (1.27)	0.34 (5.10)	0.12 (p>0.5)	57
New Zealand							
1989- 2007	0.92	0.82 (20.7)	0.15 (0.65)	0.16 (2.27)	0.10 (1.32)	0.13 (p>0.25)	75

Country	R^2	ρ (smooth)	α	β_1 (inflation)	β_2 (output)	J-stat	Observ.
Canada							
1993- 2007	0.82	0.82	0.41	0.03	0.21	0.11	56
		(24.2)	(1.63)	(0.53)	(3.60)	(p>0.5)	
Australia							
1993- 2007	0.82	0.85	0.57	0.14	0.16	0.07	59
		(39.2)	(5.85)	(4.91)	(3.61)	(p>0.9)	
Sweden							
1995- 2007	0.92	1.01	0.99	0.05	0.14	0.13	51
		(23.6)	(10.2)	(1.12)	(2.85)	(p>0.5)	
U.S.							
1988- 2007	0.95	0.93	0.61	-0.01	0.24	0.12	76
		(32.9)	(3.16)	(0.13)	(6.76)	(p>0.25)	
Eurozone							
1999- 2007	0.95	0.48	-0.26	0.23	0.69	0.13	32
		(10.7)	(0.85)	(4.97)	(17.0)	(p>0.9)	

Note: Estimating equation 3.7. The significance (t-statistics) is given in the parenthesises below the coefficients. The instruments used in this GMM estimation are the first four lags of the interest rate, the inflation level and the output gap. Japan is excluded from this test because the estimation delivers a near singular matrix and therefore no result.
Source: OECD and IFS

There are two requirements that must be fulfilled when using GMM (Baum, Schaffer and Stillman, 2003). The first is to check if the relevant instrument variables are chosen. This was carried out above when testing the joint significance of the instrument variables using the F-test (see table 3.1). The second requirement is the over-identification restriction which is a relevant issue here, since there are more instrument variables than parameters to estimate. The null hypothesis states that the over-identifying restrictions are satisfied, which means that the J-statistics times the number of observations is asymptotically χ^2 with degrees of freedom equal to the number of instrument variables minus the number of parameters to be estimated. In this estimation the degrees of freedom equal 8. Above the p-values are given in parentheses and they reveal that the over-identification restriction can only be satisfied at the 25 per cent level in the U.S. and New Zealand. Meanwhile the results look better in the Eurozone and in Australia, hence the second requirement is fulfilled.

The estimated coefficient of the smoothing parameter, ρ, is highly significant and has a very large impact on the dependent variable i.e. interest rate. In the UK the smoothing parameter has the coefficient 1.03 and is highly significant. The estimated coefficient of inflation is, on the other hand, very low and only significant at the 80 per cent level, while the coefficient of output is 0.34. Therefore it seems that the Bank of England puts most weight on interest rate smoothing while the second most

important objective is to stimulate economic growth when output is below its potential level and the third most important objective is to control inflation. This pattern can be found in all countries in the table except for New Zealand. The result for New Zealand shows that more weight is put on controlling inflation than on output since β_1 is larger than β_2. This means that among the inflation targeting and non-inflation targeting countries, New Zealand is the only country that truly has followed its inflation targeting strategy. However, even in New Zealand the smoothing parameter explains most of the variation of the policy interest rate. This implies that the central banks only adjust the interest rate gradually in small steps and that the previous interest rate is the most important factor when adjusting the interest rate. Österholm (2005), Rudebusch (2001), and Söderlind, Söderström and Vredin, (2005) are critical when it comes to the interpretation and use of the smoothing parameter. They argue that by including it, the predictability of the interest rate increases. Söderlind et al. (2005) question whether the high predictability comes from the lagged interest rate or data on the lagged inflation and output. Rudebusch (2001) argues that the large value[30] of the smoothing parameter and the high significance reflects serially correlated shocks to the economy. The results in table 3.2 show that the smoothing parameter does most of the explaining in the equation. The independent variables inflation and output seems to be less important for the policy makers compared to the smoothing parameter. The econometric estimation of the Taylor Rule will therefore proceed by excluding the smoothing parameter and estimating equation 3.5. GMM will be used and the instrument variables are the first four lags of the deviation from the inflation target and the output gap.

[30] He has found that the value varies around 0.8 by looking at historical data.

Table 3.3 Estimation of the Taylor rule without smoothing parameter

Country	R^2	α	β_1 (inflation)	β_2 (output)	j-stat	Observ.
UK						
1993- 2007	0.15	5.21	0.58	1.63	0.15	57
		(29.9)	(3.12)	(6.10)	(p>0.25)	
New Zealand						
1989- 2007	0.49	6.26	1.01	0.12	0.10	75
		(27.3)	(5.60)	(0.44)	(p>0.5)	
Canda						
1993- 2007	0.26	3.88	-0.50	0.84	0.09	56
		(23.2)	(2.19)	(3.91)	(p>0.75)	
Australia						
1993- 2007	0.14	5.52	0.36	0.21	0.017	59
		(38.1)	(3.23)	(1.10)	(p>0.99)	
Sweden						
1995- 2007	0.15	3.76	0.36	0.31	0.08	51
		(18.1)	(2.53)	(1.64)	(p>0.9)	
U.S.						
1988- 2007	0.46	4.04	0.99	0.73	0.06	75
		(11.2)	(4.81)	(3.82)	(p>0.75)	
Eurozone						
1999- 2007	0.95	2.85	-0.01	1.16	0.16	32
		(87.3)	(0.21)	(29.8)	(p>0.75)	

Note: The significance (t-statistics) is given in the parenthesises below the coefficients. The instruments used in this GMM estimation are the first four lags of the interest rate, the inflation level and the output gap.
Source: OECD and IFS

The R^2-values have worsened considerably compared to the test where the smoothing parameter was included. The over-identification has become less severe in most countries but is still persistent in the UK and New Zealand.

UK

The Bank of England seems to put more weight on controlling the output gap than the inflation rate, the estimated coefficient of inflation, β_1, is considerably smaller than the estimated coefficient of the output gap, β_2. When the deviation from the inflation target increases by one per cent the interest rate is raised by 0.58 per cent. Even though this violates Taylor's principle, i.e. $\beta_1>1$, it is still higher than 0.5. $\beta_1>0.5$ means that the Bank of England has focused more on keeping inflation close to 2 than the Taylor suggests when using his original equation (see equation 3.1). This outcome is in accordance with the graphic presentation, see figure 3.1, where it is clear that the Bank of England has set an interest rate higher than Taylor would have done over the same time period. The focus on

the output gap is much larger than on inflation. If the output gap was to increase by one per cent the interest rate would increases by 1.63 per cent.

Table 3.4 Taylor equation without smoothing parameter in the UK 2002-2007

UK	R^2	α	β_1 (inflation)	β_2 (output)	j-stat	observ.
2002- 2007	0.11	4.86 (71.4)	0.23 (1.98)	1.37 (4.51)	0.17 (p>0.9)	23

Note: The over-identification restriction is satisfied in this estimation.
Source: OECD and IFS

During the years after September 11th 2001 it seems as if the importance of keeping output growing increased and the weight on inflation decreased. In other words the Bank of England has chosen to stimulate economic growth by keeping the interest rate low.

New Zealand

In New Zealand the estimated coefficient of inflation, β_1, is larger than one while the coefficient of the output gap, β_2, is small and not even significant at the 25 per cent level. This implies that the Reserve Bank of New Zealand lets the inflation target be of the outmost importance in its interest rate decisions. This result even satisfies the Taylor principle of β_1 being larger than one and β_2 positive. Comparing this with figure 3.3, it is clear that the actual interest rate has been higher than Taylor's suggestion for the whole period. The Reserve Bank of New Zealand seems to be the most consistent inflation targeting central bank in this study.

Canada

Canada, on the other hand, seems to put negative weight on inflation, the estimated coefficient of inflation, β_1, is statistically significant and negative at the 95 per cent level which implies that if inflation was to increase by one per cent the Bank of Canada would decrease the interest rate by half a per cent. This result is not consistent with monetary policy theory and may be a consequence of the policy interest rate in 1994, figure 3.7 in the previous section shows that the interest rate was increased in 1994 even though CPI was far below from its inflation target. The regression is therefore estimated once more without the first 3 years.

Table 3.5 Taylor equation without smoothing parameter in Canada 1996-2007

Canada	R^2	α	β_1 (inflation)	β_2 (output)	j-stat	observ.
1996- 2007	0.48	3.42 (16.4)	0.55 (2.0)	0.77 (4.0)	0.09 (p>0.75)	47

Note: The over-identification restriction is satisfied in this estimation.
Source: OECD and IFS

Even though this result still contradicts the outspoken strategy, in the sense that $\beta_1>\beta_2$ it does deliver a $\beta_1>0$. This implies that if output would move one per cent away from its potential level the interest rate would be lowered by 0.77 per cent in order to stimulate the economy. And if inflation was to increase by one per cent the interest rate would be raised by 0.55 per cent. The outcome in the table above confirms the result found in the graphic test, see figure 3.6. It seems that Canada has been focusing more on stimulating economic growth and closing the output gap than on controlling inflation. Bank of Canada (2006) explains that the Canadian economy was hit by a number of negative shocks over this time period and it has been stimulating economic growth by lowering the policy interest rate.

Australia

Australia has had a more relaxed attitude towards its inflation target, nevertheless, the Reserve Bank of Australia has focused more on its inflation target than on closing the output gap. β_1 is higher and statistically significant at the 99.9 per cent level while β_2 is slightly smaller and only significant at the 50 per cent level. Nonetheless, the difference of the size of the estimators is quite small, which means that they are in parity with each other just like in Taylor's original estimation. The graphic presentation in figure 3.8, demonstrates that Taylor's suggested interest rate moves close to the actual interest rate.

Sweden

The result for Sweden looks rather similar to the result for Australia. The inflation estimator, β_1, is somewhat larger than β_2 and has a higher significance level (90 per cent) than β_2. Therefore it seems that the Riksbank puts slightly more focus on keeping the inflation level at its target than on stabilising output at its potential level. However, figure 3.9 illustrates that the Riksbank has set a policy interest rate that was lower than the Taylor rule suggests after 2002. Equation 3.5 is therefore estimated using data from 2003 to 2007, the result presented in the table below.

Table 3.6 Taylor equation without smoothing parameter in Sweden 2003-2007

Sweden	R^2	α	β_1 (inflation)	β_2 (output)	j-stat	observ.
2003- 2007	0.49	2.96 (18.3)	0.70 (4.9)	0.51 (3.2)	0.20 (p>0.9)	19
2004- 2006	0.46	1.36 (12.5)	-0.66 (2.4)	1.13 (2.1)	0.3 (p>0.95)	10*

*) The number of observations is low and the results should therefore be interpreted with some care.
Note: The over-identification restriction is satisfied in this estimation.
Source: OECD and IFS

Between 2003 and 2007 the β_1 and β_2 are different compared to the estimators found during the whole period 1995 to 2007. The Riksbank focused more on keeping inflation low than on stimulating growth during the years 2003 to 2007. β_1 is larger than β_2 and both have a higher statistical significance at the 99.9 per cent level. This result is conflicting with the low actual interest rate found in figure 3.9. One would expect the Riksbank to put more weight on the output gap than on inflation when looking at figure 3.9. This is why the same regression run for the years when the actual interest rate was considerably lower than Taylor's interest rate i.e. 2004 Q1 to 2006 Q2. The result is shown in the second row of table 3.6 above and it reveals that the Riksbank's main interest was to stimulate output during this time period. The estimator for inflation was even significantly negative which means that the interest rate was raised when inflation fell. This occurred as the Riksbank decided to get involved in the house market by increasing the interest rate despite the fact that the rate of inflation was decreasing (Riksbank, 2006).

U.S.

The result is somewhat surprising for the U.S. as it shows that the Federal Reserve Bank has focused more on controlling inflation than stabilising output, $\beta_1 > \beta_2$. It implies that if the inflation rate increases by one per cent then the Federal Reserve Bank increases the interest rate by 0.99 per cent. If output should move away from its potential level by one per cent the interest rate would decrease by 0.73 per cent. However if the same regression is run only for the years 2002 to 2007 the estimators change significantly.

Table 3.7 Taylor equation without smoothing parameter in the U.S. 2002-2007

U.S.	R^2	α	β_1 (inflation)	β_2 (output)	j-stat	observ.
2002- 2007	0.28	2.51 (7.36)	0.22 (0.74)	1.12 (4.26)	0.19 (p>0.75)	24

Note: The over-identification restriction is satisfied in this estimation.
Source: OECD and IFS

During these years stimulating the economic growth was the main objective of the Federal Reserve. This is also illustrated in figure 3.13 and 3.14.

Eurozone

The parameters estimated for the Eurozone indicate that the European Central Bank puts hardly any weight on controlling inflation and focuses all its attention on stabilising output. The estimator β_1 is almost equal to zero and not statistically significant which means that the ECB does not seem to use its second pillar which concentrates on controlling inflation. However, ECB uses the Harmonised Index of Consumer Price (HICP) and not the overall CPI to measure inflation and therefore is

equation 3.5 re-estimated using data on the HICP quarterly percentage change instead of the CPI change.

Table 3.8 Taylor equation without smoothing parameter in the Eurozone using the change in HICP

Eurozone	R^2	α	β_1 (inflation)	β_2 (output)	j-stat	observ.
1999- 2007	0.95	2.75 (106)	0.44 (4.46)	1.16 (2.98)	0.10 (p>0.95)	32

Note: The over-identification restriction is satisfied in this estimation.
Source: OECD and IFS

The estimated coefficient of the output gap has obviously not changed. But the estimated coefficient of inflation, β_1, has become higher and is significant at the 99.9 per cent level which shows that the ECB does take inflation into account when setting the policy interest rate. Nevertheless the output gap remains the most important explanatory variable.

The weights put on inflation and the output gap differs compared to what Taylor suggested in his original paper (1993) in almost every country in this study. Furthermore, the Taylor principle that states that the estimated coefficient of inflation should be larger than one, $\beta_1 > 1$, is violated in almost every case. Only New Zealand has an inflation coefficient that is larger than one. It seems that most central banks have been more concerned with closing the output gap than achieving the inflation target. The graphic presentation also reveals that the actual interest rates have been lower than suggested by Taylor, especially in recent years. With low interest rates, one would expect inflation rates to increase, however the inflation levels have not risen to alarming levels nor have they widely exceeded the inflation targets throughout the past 15 to 20 years in any of the countries in the study. Is this a sign of success of the "war on inflation" and inflation targeting strategy. Has the expected inflation level decreased as a result of inflation targeting?

Economists in favour of inflation targeting often argue that one of the benefits of credible inflation targeting is decreased inflation bias. Under inflation targeting the central banks set an inflation target. If the economic actors believe that the target will be hit and the central bank is proven to be credible in the sense that it does actually achieve the target then the expected inflation level will be equal to the set target. In the previous chapter it is shown that the interest rate in most inflation targeting and non-inflation targeting countries has been quite stable and relatively low since the mid 1990's. In table 3.9 below one can see that the average inflation levels were high during the 1970's and 1980's in all of the countries. The inflation levels have come down considerably during the 1990's and the first nine years of the 21st century.

Table 3.9 CPI development 1950-2009

UK	Mean	Variance	**Australia**	Mean	Variance	**U.S.**	Mean	Variance
1950-1959	3.5	6.9	1950-1959	6.5	47.1	1958-1959	1.8	6.7
1960-1969	3.5	1.9	1960-1969	2.5	1.8	1960-1969	2.3	2.2
1970-1979	12.6	31.5	1970-1979	9.8	16.0	1970-1979	7.1	7.1
1980-1989	7.4	20.2	1980-1989	8.4	4.5	1980-1989	5.6	13.0
1990-1999	3.7	5.6	1990-1999	2.5	4.4	1990-1999	3.0	1.2
2000-2009	2.6	0.4	2000-2009	3.2	0.9	2000-2009	2.6	1.4
Inflation Target	2		Inflation Target	2-3		Inflation Target	---	
New Zealand	Mean	Variance	**Sweden**	Mean	Variance	**Eurozone**	Mean	Variance
1950-1959	5.0	7.3	1950-1959	4.4	21.0	1950-1959	n/a	n/a
1960-1969	3.2	2.5	1960-1969	3.8	2.0	1960-1969	n/a	n/a
1970-1979	11.5	12.3	1970-1979	8.6	3.6	1970-1979	n/a	n/a
1980-1989	12.0	21.0	1980-1989	7.9	9.6	1980-1989	n/a	n/a
1990-1999	2.0	2.5	1990-1999	3.3	14.2	1996-1999	1.5	0.2
2000-2009	2.7	0.4	2000-2009	1.9	0.6	2000-2009	2.1	0.5
Inflation Target	1-3		Inflation Target	2 +/-1		Inflation Target	---	
Canada	Mean	Variance	**Japan**	Mean	Variance			
1950-1959	2.4	9.7	1950-1959	3.0	39.2			
1960-1969	2.5	1.8	1960-1969	5.4	1.8			
1970-1979	7.4	8.2	1970-1979	9.1	32.5			
1980-1989	6.5	10.8	1980-1989	2.5	5.2			
1990-1999	2.2	2.8	1990-1999	1.2	1.6			
2000-2009	2.1	0.5	2000-2009	-0.3	0.6			
Inflation Target	1-3		Inflation Target	---				

Source: IFS

Even though central banks have been focusing less on controlling inflation, inflation rates have stayed within most targets ranges (1-3 or 2 +/-1 per cent). This result can be compared with table 2.6 in the previous chapter. The variation in the inflation level has also decreased in the 1990's. This may be a sign of successful monetary policy and it seems that the central banks do not have to indulge in sharp interest rate increases in order to control rising inflation. Inflation expectations appear to have decreased due to the outspoken inflation targets made by the central banks and not by high interest rates.

However there is no striking difference between the inflation targeters and non-inflation targeters. The average inflation is for example higher in the UK and in Sweden than in the U.S. between the years 1990-1999. This can, nevertheless, be explained by Sweden's time inconsistency problem and the fact that the Riksbank was ruled by the Swedish parliament until the end of 1992. In 1990 and

1991 CPI grew by 10.4 and 9.4 per cent per year. In the UK there seems to have been a similar problem. CPI grew rapidly during the first two years of the 1990's but continued to stay above the inflation target of 2 +/-1 per cent until 1998 (the inflation target was introduced in 1992). The Bank of England was under the influence of the British parliament until 1997 which probably lead to time inconsistency problems in the UK as well.

Gürkaynak, Levin and Swansson (2006) explored whether inflation targeting had anchored inflation expectations in the UK and Sweden compared to the non-inflation targeter, the US. They used long-term bond yields and assumed that if investors are worried about high future inflation they will demand high forward nominal interest rates to compensate for future inflation. Therefore the nominal rates will respond to economic news and macroeconomic data releases. Studies that investigate inflation expectations often utilise quarterly data which limits the number of observations. By using as many as 3000 daily observations Gürkaynak et al. (2006) were able to find that the response to economic news decreased in the UK after the Bank of England gained independence. In Sweden forward nominal rates did not seem to react to economic news[31]. The sensitivity in response to economic news and data releases in the U.S. were very high which reflects a perception of a higher future inflation. Hence inflation targeting seems to have anchored inflation expectations and actual inflation levels and variance in the UK and in Sweden but not in the U.S. This supports the assumption that inflation targeting does lower expected and future inflation.

3.5 RESULTS

The purpose of this chapter was to find whether the inflation targeting countries in this study put more focus on keeping inflation close to its target than on closing the output gap. Out of the five inflation targeting countries in this study, three seem to put more focus on controlling inflation rather than on closing the output gap. However, the variation of focus is not as great as one might expect. New Zealand is the only country that delivers a result which shows a distinct difference in size of the estimators and it seems to be the only country that has conducted an uncompromised inflation targeting strategy. Sweden and Australia have focused almost equally much on stabilising output and on controlling inflation. Canada and the UK do not focus their monetary policy on controlling inflation, in fact, their main objective has been to close the output gap. The U.S. which has no inflation target seems to have been more concerned about low inflation than about the output gap. This can be seen when running the regression for the time period 1988 to 2007. However, after

[31] The data-set for Sweden does not stretch back to the time before inflation targeting was introduced which makes it impossible to find a change in behaviour with respect to the implementation of inflation targeting.

2001 the Federal Reserve Bank has boosted economic growth by easing monetary policy and letting inflation run high (4.7 per cent in Q3 2005). This implies a changing behaviour after 2001. The Eurozone also appear to have focused more on stimulating economic growth than on controlling inflation.

Even though the inflation targeting countries have focused less on their inflation targets than one might expect they have successfully decreased their average level of inflation over the past 15 years. This implies that the inflation targets have gained credibility and that the central banks do not have to raise interest rate according to Taylor's principle in order to control growing inflation. This raises many questions and one of them will be discussed in the next chapter; what effect do low interest rates have on house prices?

4 THE ROLE OF MONETARY POLICY IN THE CURRENT FINANCIAL CRISIS

4.1 INTRODUCTION AND PURPOSE

The results in the previous chapter show that most of the central banks in the countries studied have set policy interest rates relatively low compared to the interest rates calculated by using Taylor's rule between the years 2001 and 2006. Belke and Klose (2010) have found a similar result, by using a state-space model and GMM to estimate the Taylor rule for the U.S. and the Eurozone. Both the European Central Bank and the Federal Reserve Bank have violated the Taylor principle during the years 1999 to 2007 i.e. the estimated coefficient for inflation has been lower than one. These findings imply that the central banks have run a monetary policy that has focused more on stimulating output growth than on controlling inflation.

Economist John B. Taylor (2007 and 2009) argues that the loose monetary policy in the U.S. was the reason for the booming house market that finally collapsed. He criticises the loose monetary policy of the Federal Reserve and blames the Federal Reserve for not being able to control the "unhealthy" development of house prices and house starts.

Lars E. O. Svensson (2010) disagrees with Taylor and calls on additional control of the lending sector in order to regulate the prices in the house market. His view is that the central bank should be responsible for creating stable prices by using inflation targeting since stable prices is an important prerequisite for economic growth. At times of slow economic growth the central bank can temporarily leave its inflation target in order to push output growth. This he calls "flexible inflation targeting". Hence the priorities of the central bank should be primarily to control inflation and secondly to control output. Controlling house prices is not a task for the central bank according to Svensson. If the policy makers want to control the house price development they should enforce regulations that can cool off rapidly rising house prices.

It is difficult *not* to agree with both economists but their discussion leaves room for further research. Could the current financial crisis have been avoided if the Federal Reserve Bank had raised its policy interest rates sooner and to a higher level? Measured by CPI, inflation did not indicate that the American economy was significantly overheated. In 2006, CPI grew by 3.2 per cent in 2007 by 2.9 per cent and reached 3.8 per cent in 2008, hence inflation was not startlingly high[32]. The U.S. does not pursue an outspoken inflation targeting strategy and they have expressed that they will not let

[32] The CPI in the U.S. has been growing around 3 per cent per year since 1983 (IFS).

economic growth suffer in order to control inflation, even though the Federal Reserve is trying to keep inflation low (Sardoni and Randall Wray, 2006).

How does one detect monetary excess, asset and house price bubbles and does the detection lie within the responsibility of the central bank? This chapter will not answer this question but it intends to investigate whether and how monetary policy has played a role in the current financial crisis. Is there a clear relationship between house prices and monetary policy? Could the house price boom in the U.S. and other countries have been avoided if interest rates would have been set higher? Should monetary policy take an active role in controlling house and asset prices?

The chapter is ordered as follows. The following section presents an overview of previous research. Part (4.3) explains some basic theory regarding house prices. The empirical analysis is found in the third section. The first part of the empirical analysis explains the framework and data selection while the second part explores the relationship between the policy interest rate and house prices. This will be done by using a vector error correction (VEC) model. The following section explains how the subprime market in the U.S. worked and works and how the financial crisis could come about with such magnitude as it did. The question that will be answered is whether loose monetary policy is to blame for the latest financial crisis.

4.2 PREVIOUS RESEARCH

The current crisis began as a subprime crisis due to a booming housing market in the U.S. and therefore Taylor (2007) investigates the connection between monetary policy and the number of house starts and increasing house prices in the U.S. market. Taylor (2009) argues that if the interest rate had been set higher the number of house starts and the prices would not have boomed as they did and consequently the bust would have been avoided. The number of house starts increased from 1.5 million units in 2001 to more than 2 million two years later in the U.S. according to Taylor (2007). During these two years the house prices also increased rapidly. In his study he starts off by assessing a counterfactual federal funds rate which is calculated by using the Taylor rule (similar to the estimations in the previous chapter of this thesis). Taylor finds that the counterfactual interest rate is higher than the actual Federal Funds rate over the years 2002 until the start of 2006 (figure 3.13 illustrates Taylor's suggested Federal Funds rate calculated in this thesis). He then estimates how many house starts that would have begun if the Federal Funds rate had been set according to Taylor's counterfactual rate. Based on historical estimates of house starts with respect to the Federal Funds rate Taylor estimates a relationship between the Federal Funds rate and the number of house starts. He then uses the relationship to model how many house starts that would have been observed

if the Federal Funds rate had been set according to Taylor's counterfactual interest rate. The result shows that with Taylor's higher counterfactual interest rate the number of house starts would have reached its peak of 1.8 million units at the end of 2003. In reality the number of house starts reached its peak in the beginning of 2006 when the number exceeded 2.1 million units. Hence with Taylor's counterfactual interest rate the number of house starts would have been lower and the development of the house bubble might have been avoided, as a higher interest rate could have cooled off the market. Taylor (2009) therefore argues that among many other circumstances the low Federal Funds rate has been responsible for the house price bubble which was the spin-off for the international financial crisis. Svensson (2010) disagrees and claims that the current financial crisis was not caused by loose monetary policy but by

…"distorted incentives in financial markets, regulatory and supervisory failures conducted when central banks have been responsible for regulation and supervision, information problems and some specific circumstances, including the U.S. housing policy to support home ownership for low-income households" (p. 3, Svensson 2010).

Bean (2009) also writes that it is impossible to blame the financial crisis solely on monetary policy. However he does mention loose monetary policy to be one contributing factor. Bean, furthermore, states that financial booms and busts have occurred ever since the Tulip Mania in the 17th century and acknowledges that macroeconomic models seldom take financial frictions into account. Booms and busts are a common feature of capitalist economies and he calls for further research that can develop models which deal with financial frictions instead of treating them as an unlikely event. Bernanke, Gertler and Gilchrist (2000) furthermore recognise that asset price dynamics can cause macroeconomic fluctuations that central banks may want to respond to.

Bean (2003) argues that strict inflation targeting is not enough for central banks to avoid financial imbalances. However flexible forward looking inflation targeting is. When looking at the monetary policy objectives of the major inflation targeters he finds that the banks follow two objectives i.e. reaching the inflation target and minimising the output gap. With a flexible and forward looking inflation target the bank can incorporate consequences of asset price bubbles and financial imbalances when it sets the policy interest rate. Hence, the central bank should analyse the question of how asset prices affect the outlook of economic growth and inflation. In this sense he argues that monetary policy has to take financial imbalances into consideration when setting the policy rate. Furthermore he acknowledges that since the introduction of inflation targets many inflation targeters have experienced both low expected and realised inflation. Borio and Lowe (2002) argue that a "low inflation environment" makes it more difficult to identify economic imbalances. They argue that imbalances that develop under low inflation may cause financial booms and busts that have major consequences for the real economy. Bean (2003) already identified a potential imbalance

in the UK, which was that household spending grew faster than output growth and household debt also grew quickly as house prices rose.

In accordance with Bean (2003), Tucker (2008) argues that monetary policy must continue its objective to stabilise prices. But also recognises that there is a need to further investigate how asset prices and risk premiums affect the real economy and to integrate this into the macroeconomic forecasting models of the central banks. Assenmacher-Wesche and Gerlach (2009) have studied property prices and monetary policy in 18 OECD countries from 1986 to 2008. They find that it is tricky to control increasing property prices by tightening monetary policy since it will influence economic growth. The outcome of their panel vector autoregression (VAR) estimates show that if interest rates are increased by 0.25 per cent house prices will successfully decline by 0.18 per cent but real GDP will, unfortunately, decrease by 0.12 per cent. This illustrates the problem of trying to interfere with house prices by using the policy interest rate.

Mishkin (2007a) warned that, although the housing market has not been the main topic of concern in previous cases of financial instability in the U.S., the current development in the house market could prove to be different. Nominal house prices rose by 7 per cent per year between 1996 and 2005. During the same time liberalisation, deregulation and financial innovation took place and this kind of development has often led to previous lending booms according to Mishkin. In his paper he states that various econometric models developed by the Federal Reserve Board's staff are not able to fully explain the booms and busts of residential house prices and construction. It is even difficult to determine how house prices respond to changes in the interest rate and to find fundamentals that steer the house price development. Mishkin therefore argues that monetary policy should not try to control house prices, it may cause confusion in countries where the central banks have outspoken policy objectives. If a central bank decides to respond to sharply rising house prices it can do more harm than good. Hence, a central bank should observe the house price movements and be prepared to reduce the negative effects that falling house prices might have on the aggregate economy.

Detken and Smets (2004) have derived some "stylised facts" of monetary policy, asset price booms, and the aftermath. They define asset price booms as a 10 per cent positive price deviation from its recursively estimated trend price. According to this method there have been 38 boom periods in 18 OECD countries between 1970 and 2004. Detken and Smets also find that not all booms result in bubbles bursting and financial crises. Therefore they divide the booms into high-cost booms, i.e. booms that led to large recessions, and booms that did not, i.e. low-cost booms. What the booms have in common is that both equity and real estate prices rise strongly during the boom only to fall after the boom. GDP which also grows throughout this time period is mainly pushed by private investment that includes house investment. The increasing house investments are escorted by increasing real credit growth. High-cost booms last up to one year longer than low-cost booms in which time the

deviations from the trend asset prices are 3.5 per cent higher than in the low-cost booms. Money and credit growth is higher in the periods prior to the boom years in the high-cost booms. Detken and Smets find deviations from the Taylor rule which shows that monetary policy has been looser than normal during the boom period in both high- and low-cost booms. Their conclusion is that monetary policy cannot be blamed for triggering or allowing asset booms. Yet, they write somewhat vaguely that they are tempted to argue that high inflation is related to high-cost booms.

Adalid and Detken (2007) continue the investigation of asset price booms and busts by including the house market and additional years in their study. By using cross-country analysis they find that excess liquidity has a positive effect on house prices. They attempt to find the reason how and if liquidity shocks lead to booming asset prices with the help of a number of different econometric techniques. They find that house price developments in boom and bust periods help explain the recession following the booms. Furthermore they find a positive relationship between money supply and asset prices when pooling together their whole data sample.

Belke et al. (2010) study the transmission of international monetary shocks and its effects on money supply (liquidity), and consumer and asset prices. They use VAR analysis over the years 1984 to 2006 in order to answer the question whether global monetary conditions have an effect on house price dynamics. Their quarterly observations include data from OECD countries that together make up more than 72 per cent of the world's GDP in 2006. The result from the benchmark model which includes GDP, inflation, short-term interest rate and aggregate money supply (liquidity) shows that interest rate shocks affect output negatively. Conversely liquidity shocks have a positive effect on output. Belke et al. (2010) continue by including house prices in the benchmark model. The result in this case shows that house prices respond to movements in the interest rate and global liquidity. Hence they conclude that loose monetary policy and plentiful global liquidity has contributed to increasing house prices.

Tsatsaronis and Zhu (2004) reach the conclusion that house prices depend both on inflation and the mortgage interest rate. They use cross-country analysis and find that in countries where floating mortgage interest rates are widely used the sensitivity of the interest rate on the house prices is higher than in countries where long-term or fixed mortgage rates are more common. They also find that households are more sensitive to the nominal amount of monthly costs of owning a house than to the size of the loan compared to the households' income. A somewhat surprising outcome is that inflation, measured as CPI growth, has a strong positive impact on real house prices. The second most important impact on house prices is that of real short-term interest rates, term spread[33] and the

[33] Tsatsaronis and Zhu (2004) define term spread as the difference in yield between a long-maturity government bond and the short rate (p. 71).

growth of bank credit. These results are derived from data on 17 industrialised countries over the years 1970 through 2003 by using VAR-analysis.

The previous research presented above investigates the technical macroeconomic variables without looking at the incentives for banks to push asset prices. Herring and Wachter (2003) investigate the bank management's behaviour and their incentives for pushing property prices in the real estate sector. Banks hold real estate as assets on their own balance sheet and the value of these assets is the bank's collateral. If the value of the collateral increases, the banks are able to increase their lending to the real estate industry. If they increase their lending to more real estate this is likely to increase the price of real estate. Hence, lending to the real estate sector is attractive to the bank if prices are likely to increase as the bank can lend out more money and collect interest on a higher number of loans. However if prices start to fall the bank starts to encounter problems. According to Herring and Wachter, the bank's problems may spread to the whole economy depending on how dominant a role the banking sector has in a country's financial system. Before the Asian crisis Japanese banks held 79 per cent of total assets in real estate. When real estate prices fell the banking crisis spread to the real economy.

There are many cross-country studies which find that the interest rate affects the house prices e.g. Gies and Tuxen (2007), Björnland and Jacobsen (2008), and IMF (2004). However, this study intends to extend the research by looking at differences between countries. Does the relationship between house prices and exogenous variables vary from country to country? What is the explanation for this variance? Secondly it will explain the mechanisms of the mortgage market, and the subprime market, in the U.S. and answer the question how the relatively small subprime market could cause a full blown international financial crises?

4.3 WHAT DETERMINES THE DEVELOPMENT OF HOUSE PRICES?

The price of residential houses (referred to as houses in this paper) is like the price of most other goods, a matter of supply and demand. The supply of houses is the existing stock of houses. The demand for houses is assumed to increases as households become wealthier. Houses can also be seen as an asset, which leads to increasing demand for houses if it is considered to generate a relatively attractive real rate of return compared to other investments e.g. stocks or bonds. Furthermore the demand for houses depends on the net real return of owning a house. The gross return consists of rent if the house is let out and the gains from increasing value of the house. The costs of owning a house are mortgage interest rate, real estate tax and depreciation (Dornbusch, Fischer, and Startz, 1998). Dornbusch et al. (1998) argue that monetary policy decisions have

"powerful" effects on house investments since the demand for houses is sensitive to mortgage interest rate. When investigating U.S. data from 1960 to 1996 they find that the real interest rate has considerate effects on the monthly costs of owning a house. Although, the level of real estate tax also plays a role for the house costs. The U.S. tax system allows house owners to deduct their house costs i.e. the nominal interest rate on the mortgage, from their personal income tax. This implies that if the nominal interest rate is high and inflation is high the household can deduct larger house costs from their personal income tax then in times when the inflation level is low and the nominal interest rate is high. Hence high inflation and low levels of real interest rate makes home owning attractive and increases the demand and price of houses.

Let us look at how the monetary transmission mechanism affects the house market according to capital theory inspired by Mishkin (2007a). As explained above neoclassical models view the cost of capital as a major determinant for the demand of houses. The cost of capital for the use of a house (*uh*) can be described as follows

$$uh = hp\left[(1-t)i - \pi_h^e + \varphi\right] \tag{4.1}$$

Where *hp* is the purchase price of the house, *t* represents the real estate tax, *i* is the mortgage interest rate, π_h^e is the expected rate of appreciation of the house price and, φ is the depreciation rate for the house. Hence the cost of capital depends on the price of the house, the real estate tax, the expected appreciation of the house price, and the depreciation rate of the house. By subtracting the expected inflation rate, π^e, the user cost of capital can be rewritten in terms of after tax and real interest rates

$$uh = hp\left[\{(1-t)i - \pi^e\} - \{\pi_h^e - \pi^e\} + \varphi\right] \tag{4.2}$$

Investing in a house can be considered a long-term investment which implies that the mortgage rate reflects a long-term interest rate. If the house owner has a variable-rate mortgage the variable-rate will reflect the average mortgage rate over the whole borrowing period since the monetary policy rate influences the short-term interest rate which in its term affects the expected future interest rate and eventually the long-term interest rate. In other words the short-term interest rate will play an important role for the cost of capital despite if you have a fixed-rate or variable-rate mortgage. In this model Mishkin does not consider the aggregate money supply and its effect on the demand of houses. Belke et al. (2010), who consider aggregate money supply, reason that if money supply increases and the interest rate is low then the mortgage rate will decrease, thereby decreasing the user cost of capital. This will lead to "inexpensive" user cost of capital for owning a house; hence demand for houses will increase.

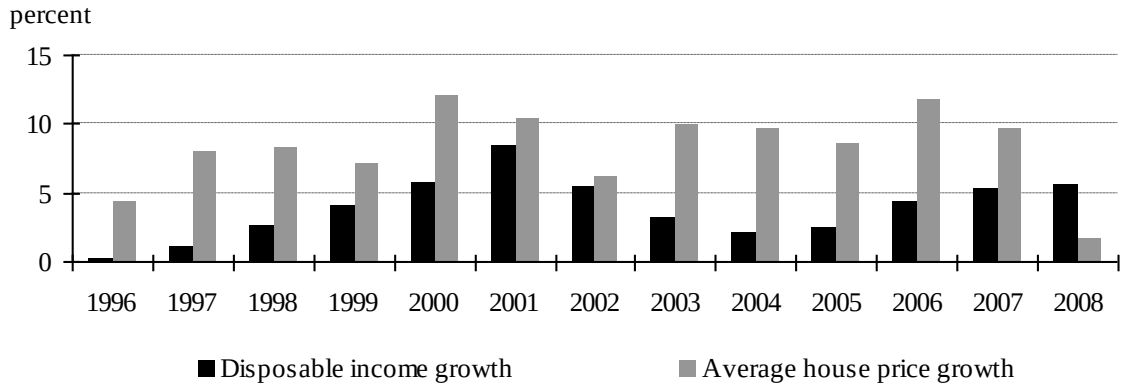
House prices move in long-term cycles according to Gros (2007), as they are heterogeneous products. They have different size/number of rooms, different standard/age, and are built on different locations which are more or less attractive. Houses are commonly large investments that involve high transaction costs. The transaction costs vary between countries but include agents' and legal fees and transaction taxes. In Europe transactions are generally subject to value added tax. This makes house prices quite predictable and less volatile in the short run. These characteristics can be compared to those of more homogeneous products e.g. stocks. Stocks are traded with transaction costs, but they are only a fraction of a per cent. It is possible to observe the change in prices on the stock market on daily basis and they are easily traded. Hence houses can be considered a long-term asset where prices move slowly.

House prices and disposable income an illustration of the development in Sweden

The Swedish Riksbank is an inflation targeting central bank that has kept a close eye on the increasing house prices in Sweden. They even raised the policy rate at one occasion in an attempt to cool off the housing market even though their own inflation forecast was revised downwards (Riksbank 2006). The Riksbank started to observe the housing market with greater care after the financial crisis in Sweden at the start of the 1990's according to Wickman-Parak (2009). Among many factors that caused the Swedish financial crisis in 1992, one important factor was the banks' lending to the property sector[34]. According to rough estimates 2/3 of the private banks' credit losses came from the property sector (Riksbank, 2009). Between the peak in 1989 and the lowest point in 1993, prices of commercial property decreased by 70 per cent in the centre of Stockholm which created great problems for the Swedish banks. Even though lending to property companies makes out a considerably smaller portion of the Swedish banks today the Riksbank started to "hear the alarm bells" when observing the rapidly rising house prices in Sweden. Prices for small houses have risen by almost 160 per cent between 1996 and 2008 while the households' disposable income has increased by only 65 per cent (Statistics Sweden, March 2010).

[34] Lending to property companies made up 1/3 of total lending during the previous crisis in Sweden (Riksbank 2009).

Figure 4.1 Annual growth of disposable income and house prices in Sweden



Source: Statistics Sweden (March 2010) and Reuters Ecowin

In the figure above it is plain to see that the disposable income has grown considerably slower than the average house prices between 1996 and 2008. The difference in growth is particularly large and sustainable after 2002. This is the starting point of the actual policy rate being lower than what Taylor would suggest (see figure 3.9). This gives some indication that the low policy rate might be a contributing factor to the increase in house prices.

Regulation and control of house lending

An additional factor that decides the demand for houses are regulations that control how much households are allowed to borrow. This can be seen by looking at the deregulation of the credit market that started in most industrialised countries in the 1980's. The deregulation has led to more generous lending conditions and a higher availability of mortgage debt. Until the 1970's mortgage lending was controlled by prevailing regulations and the size of the mortgages could almost not be increased even if the financial institution was able to secure the loans with higher values of assets. It was also restricted to specific financial institutions that were specialised in mortgage lending (Claus and Scobie, 2001). By the mid 1980's the constraints were loosened and financial institutions in Canada, Australia, UK, New Zealand, Sweden and the U.S. were allowed to enter the mortgage market without interest rate and quantitative regulations on mortgages. Japan and some European countries experienced a slower deregulation. In Germany the financial system became more liberalised already in the 1970's but this did not lead to a significant increase in mortgage lending. The residential mortgage market in Germany was mainly run by publicly owned financial institutions which benefited from generous financing conditions as they were guaranteed by the public finances (OECD, 2000). However, high regulatory requirements on the house market that alleviated the effects on the house market (Belke, 2010). In recent years foreign financial institutions have entered the German financial market and the mortgage conditions (e.g. the size of the down-payment) are becoming less strict.

4.4 EMPIRICAL ANALYSIS

This part of the thesis asses to what extent the policy interest rate affects house prices by using data on the UK, New Zealand, Canada, Australia, Sweden and the U.S. The Eurozone will be excluded as there does not exist a house price index for the entire Eurozone and the house prices have developed very differently in the individual Eurozone countries. Commonly house purchases are financed by borrowing, using the house as collateral. This financing makes house owners sensitive to their borrowing conditions, e.g. the interest rate and other regulations.

4.4.1 EMPIRICAL FRAMEWORK

Iossifo, Čihák and Shanghavi (2008) have investigated the determinants of house prices in 20 advanced economies by using econometric cross-section modelling. They begin their study by presenting an extensive overview of previous empirical research which finds that the short-run interest rate has an influence on house prices. However, this impact varies from zero to minus eight in the different studies. The result of Issifov et al. (2008) own research shows that if the short-term interest rate is increased by one per cent, the growth of residential house prices will decline by 0.24 per cent. They employ a model that uses endogenous explanatory variables in addition to the lagged dependent variable. From their overview of previous empirical research and the previous findings presented in this chapter the following explanatory variables have been chosen:

- Disposable income (*di*)
- Aggregate money supply (*M2, M3, M4*)
- Inflation (*cpi*)
- Policy interest rate (*i*)
- Private and housing credit (*cred, mor*)

Aggregate money supply is measured by M3 in all countries except in the U.S. and the UK where M2 and M4 respectively are used. The growth of CPI represents inflation. The interest rate used in most econometric estimations is the short-term interest rate. As the purpose of this thesis is to estimate the relationship between the policy rate and house prices the short-term interest rate will be substituted by the policy rate. The short-term interest rate is very sensitive to the changes in the policy rate and they commonly move in a similar pattern, see table 4.1 below. Therefore it is possible to use the policy rate instead of the short-term interest rate.

Table 4.1 Correlation between the policy rate and 3-month short-term interest rate

Country	Time period	Correlation coefficient
Australia	1986 Q2-2010 Q2	1.00
Canada	1981 Q1-2010 Q2	0.99
New Zealand	1989 Q4-2010 Q2	0.96
Sweden	1982 Q1-2010 Q2	0.97
UK	1978 Q1-2010 Q2	0.99
U.S.	1970 Q1-2010 Q2	0.99

Source: IFS

This is the relationship that this study aims at estimating

$$hp_t = \alpha + \beta_1(di_t) + \beta_2(i_t) + \beta_3(Mn_t) + \beta_4(cred_t) + \beta_5(CPI_t) + \beta_6(hp_{t-1}) + \varepsilon_t \quad (4.3)$$

where $n = 2,3,4$ depending on which country is tested.

A log-linear model will be applied as the purpose is to find the elasticity of the house prices with respect to the explanatory variables:

$$\ln hp_t = \alpha + \beta_1(\ln di_t) + \beta_2(\ln i_t) + \beta_3(\ln Mn_t) + \beta_4(\ln cred_t) + \beta_5(\ln CPI_t) + \beta_6(\ln hp_{t-1}) + \varepsilon_t \quad (4.4)$$

The regression model will be run for each country individually. The reason for this is to avoid incorrect estimation results that may relate to house price indices which are measured in different ways in different countries (see Iossifov et al., 2008). In addition cross country analysis can become complicated since the credit conditions vary from country to country. House loans can be subject to long-term fixed interest rates and short-term variable interest rates. In countries such as France, Germany, and Austria most house loans are set at fixed rates which makes them less sensible to changes in the interest rate. In Australia, New Zealand, the UK, and Sweden the majority of house loans are either completely variable or fixed between one and five years (Calza, Monacelli and Stracca, 2007). Even if this is an interesting observation it does not change the influence on the house prices since the interest rate is known to the buyer at the time of the house purchase and will therefore have an impact on the house price despite if the interest is a fixed or variable rate.

The following part of this section will assess what effect the interest rate has had on house prices in five OECD countries. Four of the countries pursue inflation targeting and one is a non-inflation targeter. House prices are included in the consumer price index which is used to measure inflation. One would assume that inflation targeting countries should automatically be able to control house

prices since they target an inflation rate which includes house prices. However, as can be seen in the example of Sweden above, it does not always seem to be the case.

Data selection

The data used in this empirical test is quarterly and the time period ranges from 1981 to 2010 but the exact time differs between the countries. The data on house prices and disposable income are generated from Reuters EcoWin, the time series on the interest rate, money supply, and private credit was downloaded from IMF's IFS. Private credit data is defined as "Banks claims on the private sector" in the IFS database but did not have data on all countries. The Swedish data series on private credit originates from Statistics Sweden and represent loans given by housing credit institutions to households. The data on Canada's mortgages was purchased from Statistics Canada and shows the growth of mortgages in Canada. The U.S. private credit data originates from Federal Deposit Insurance Corporation and measures the total outstanding real estate loans secured by family residential properties. The major part of the data generated was seasonally adjusted, in the cases where it was not, Eviews X12-ARIMA procedure has been used.

4.4.2 ECONOMETRIC SPECIFICATION

Estimating equation (4.4) with the help of common OLS shows that the time series are strongly positively serially correlated. Furthermore the series seems to be non-stationary and trending. Indications of non-stationarity (also known as unit root problems) are very high R^2-values and low t-statistics for the individual variables. Estimating the equation by using OLS when the series are correlated gives spurious or nonsense regressions that do not reveal much about the real relationship between the variables (Ito, 2008). Therefore, a vector error correction (VEC) model will be used. VEC models are restricted vector autoregressive (VAR) models and are appropriate for estimations that involve non-stationary data series that are cointegrated. VAR models are often employed by economists[35] when estimating monetary policy effects on the economy since the model treats all variables endogenously. By treating the variables endogenously it is possible to identify relationships that might appear between the variables on the right and left hand side of the equation. A stationary VAR model with *p* lags is specified as (following the notation of Hendry and Juselius, 2000 and Hamilton, 1994):

$$x_t = \pi + \Pi_1 x_{t-1} + \Pi_2 x_{t-2} + \cdots + \Pi_p x_{t-p} + \varepsilon_t \qquad (4.5)$$

[35] For example Fung (2002) and Goodhart and Hofmann (2008).

Where x_t represents a p-vector of stationary and endogenous variables, t=1,..., T, and the parameters, $\Pi_{1,}...\Pi_p$, are constant coefficients with full rank. ε_t represents white noise and is assumed to be normally distributed with zero mean and has a symmetric variance-covariance matrix. However, if the variables are non-stationary the coefficient matrices do not have full rank. When a matrix has full rank it means that all the vectors in the matrix are linearly independent from each other. Hence if the coefficient matrices in equation 4.5 have reduced rank r<p there is a linear relationship in the vectors and it is a sign that the variables are cointegrated with each other (Engel and Granger, 1987). The coefficient matrix can then be written as:

$$P = \alpha\beta' \tag{4.6}$$

where α and β are p x r matrices with reduced rank r. The VEC model can then be specified as:

$$\Delta x_t = \pi + \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_{p-1} \Delta x_{t-p+1} + \mathrm{P} x_{t-1} + \varepsilon_t, \tag{4.7}$$

where P is the cointegrated matrix which represents the long-run (cointegrated) relationship in the equation, i.e. $P = \Pi_1 + \Pi_2 + \cdots + \Pi_p$. The coefficient matrices denoted by Γ show the short-run relationship between the variables.

A prerequisite for variables to be cointegrated is that they are independently showing non-stationary patterns i.e. the time series have a unit root. By using the Augmented Dickey-Fuller test the time series were checked for unit roots. Appendix 4, presents the results which show that most of the time series have a unit root[36]. When tested for cointegration by using Johansen's cointegration test all the series seem to be cointegrated (see appendix 5). Series are said to be cointegrated when a linear combination of more non-stationary time series becomes stationary. The Johansen method developed by Johansen (1991 and 1995) is applied by using the Eviews package. It is based on likelihood estimation that calculates the rank of matrix Π which, in turn, reveals the long-run relationship between the variables (Eviews, 2009).

The vector of endogenous variables that will be tested is ordered accordingly: $hp_{t-1}, (di, cpi, cred, Mn, i)_t$

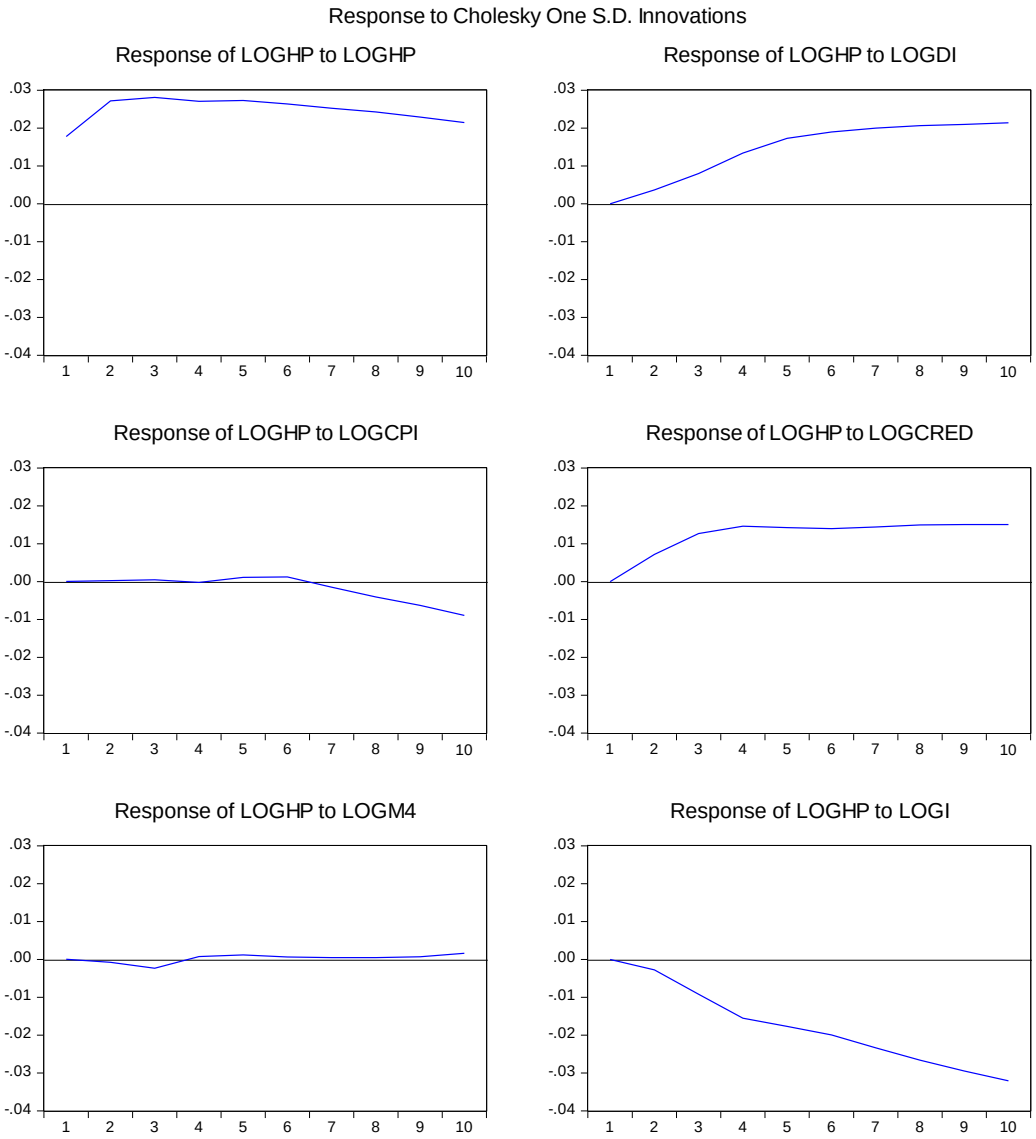
The results will be described individually for each country bellow.

[36] Some of them have a weak or no unit root and this is a shortcoming of the empirical analysis.

Empirical result for the UK

The time period tested for the UK stretches from 1989 Q1 to 2010 Q1. The time series have four cointegrating relations. Below follows the impulse response analysis for the UK

Figure 4.2 Impulse response analysis for the UK



Note: F-stat: 7.75, Adj. R^2: 0.58

Source: Reuters EcoWin and IFS

The impulse response graphs above show that increasing house prices have a positive effect on future house prices. Neither inflation nor monetary supply has a direct effect on house prices. Rising inflation even affects house prices negatively after 2 years. Iossifov et al. (2008) also find that inflation has a negative effect on house prices. Assuming that rising inflation leads to a higher interest rate, which is the case in inflation targeting countries. Since a raised interest rate lowers

house prices, then increasing inflation implicitly theoretically should lead to declining house prices. The figure above illustrates that, in this case, it does.

The data on M4 is exceptionally volatile and the correlation between M4 and house prices is very low which might explain why money supply does not seem to influence house prices in the UK. Furthermore, the house price data in the estimation stems from the nationwide house price index. The Nationwide house price index measures the house prices on properties that are financed by loans (Financial Times, 2010). It thereby excludes properties financed through cash or by other lenders and may be a partial explanation as to why money supply does not affect house prices measured by the Nationwide index.

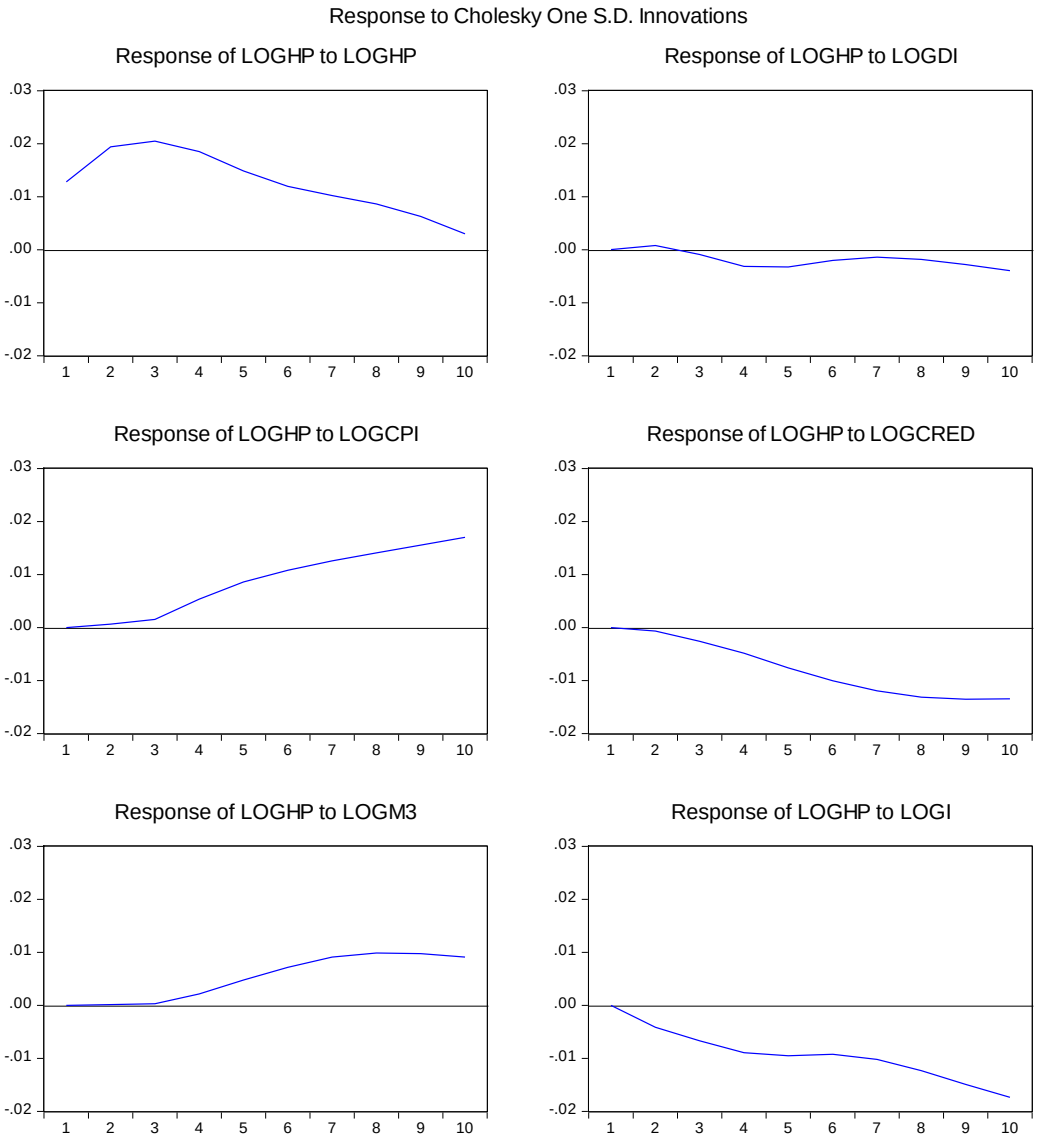
As expected, a positive shock in the disposable income affects house prices positively over the whole 10 quarters. Increasing bank's claims on the private sector, which is used as a proxy for measuring the size of outstanding loans to households, also affects house prices positively. Hence if private credit increases so do house prices.

The most central question in this study is to determine whether house prices are affected by tighter monetary policy. In the case of the UK it is safe to say that house prices decline when the interest rate is raised.

New Zealand

The data for New Zealand ranges from Q1 1989 to Q4 2009. The impulse response functions give the following result. The time series have three cointegrating equations.

Figure 4.3 Impulse response analysis for New Zealand



Note: F-stat: 7.02, Adj. R^2: 0.56
Source: Reuters EcoWin and IFS

Just as in the case of UK increasing house prices have a positive effect on future house prices, however the effect fades over time. The inflation rate and aggregate money supply have a significant positive effect on house prices after a few quarters. This does not conform to the result in the UK.

Disposable income and the amount of credit in the private sector deliver a negative effect on house prices. Disposable income is a tricky variable since it can give misleading results depending on how it is defined. According to the international standards of national accounting, profits made on capital assets e.g. shares and houses do not increase disposable income. If you for example make a US$ 100,000 profit on your investment in the stock market, your disposable income will decrease by US$ 30,000 under the assumption that the tax rate on capital is 30 per cent. This is because taxation

reduces your disposable income and the profit on investment raises your personal wealth but not your disposable income. This might explain the negative relationship between disposable income and house prices. If the price of houses increase quickly, as they have done in many of the countries in this study, the disposable income will decrease when large profits are made on sales of the houses as these profits are subject for taxation. We will encounter similar results in the analysis of Sweden and the U.S.

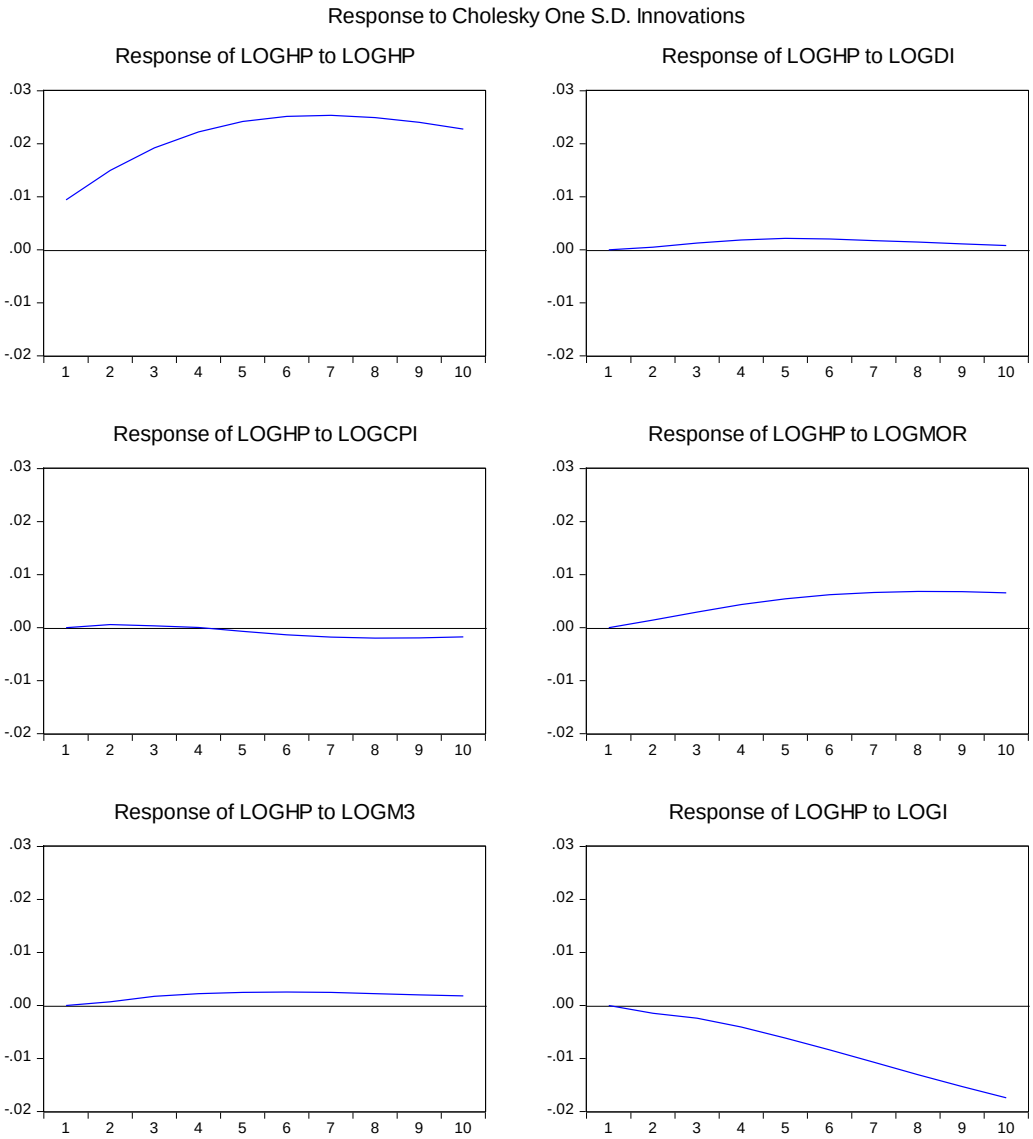
Figure 4.3 further shows that increasing credit leads to declining house prices. This is an unexpected result that does not conform to economic theory. It is difficult to find a reliable explanation for this, but looking at the results for Australia we see a similar picture. House prices in Sweden and in the U.S. do not seem to be particularly affected by increasing amounts of credit either.

Nonetheless, the central finding on what effect the interest rate has on house prices shows that an increasing interest rate causes house prices to decline in New Zealand. In other words, tighter monetary policy will make house prices decline in New Zealand.

Canada

The time period tested stretches from Q1 1981 to Q1 2009. Johansen's cointegration test shows that there are 3 cointegrating relations in the data. Impulse response analysis for Canada follows.

Figure 4.4 Impulse response analysis for Canada



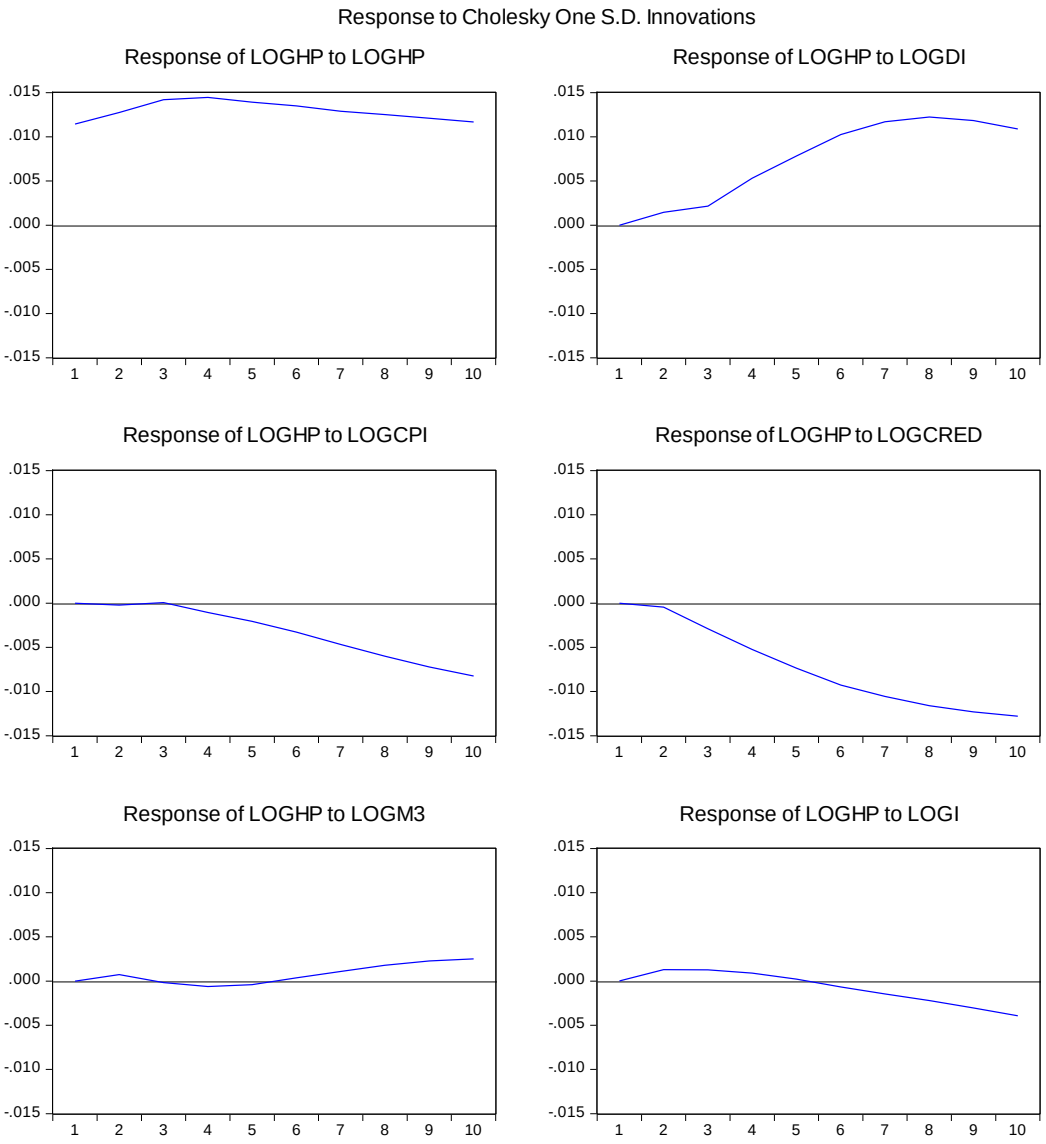
Note: F-stat: 10.01, Adj. R^2: 0.56. Mor stands for mortgages
Source: Reuters EcoWin, IFS and Statistics Canada

House prices seem to increase due to positive shocks in previous house prices, aggregate money supply, disposable income, and increased mortgage lending. These findings do not come as a surprise and neither does the outcome that house prices drop as a response to higher interest rates. We see again that increasing inflation has a negative effect on house prices after 4 quarters which further strengthens the reasoning in the case of the UK above (i.e. increasing inflation will probably lead to raised interest rates which depresses house prices). The overall impulse response analysis for Canada corresponds very well with the theory on house prices and will not be commented further.

Australia

The data for Australia ranges from Q2 1987 to Q4 2009 with missing values between Q2 and Q4 1997. Johansen's cointegration test results in 2 cointegrating relations. The impulse response analysis follows below.

Figure 4.5 Impulse response analysis for Australia



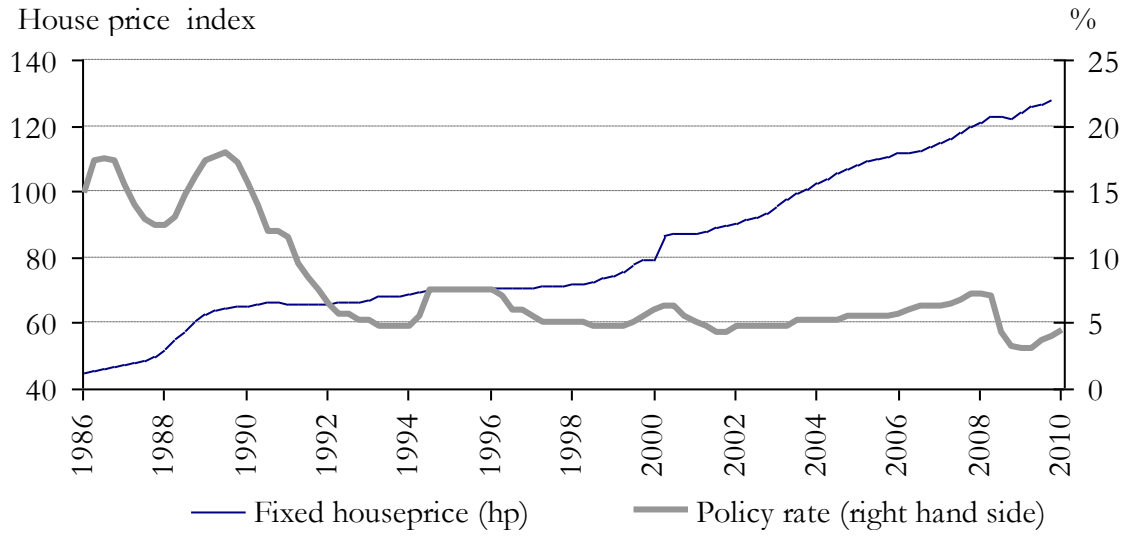
Note: F-stat: 2.67, Adj. R^2: 0.35
Source: Reuters EcoWin and IFS

As in the analysis of the countries above, present house prices affect future house prices. The effect of inflation is negative after only 3 quarters. Shocks in the aggregate money supply have positive effects on house prices after one and a half years. An increase in disposable income seems to give house prices a major push. The significant relationship might be explained by the fact that house prices have not grown as rapidly in Australia as in the other countries in this study (see figure 4.9). This

suggests that house prices in Australia may have been growing more in line with the households'' disposable income.

As can be seen in Australia's neighbouring country New Zealand, a rising amount of credit claims on the private sector has a strong negative influence on house prices. An additional unexpected result is that higher interest rates seem to deliver higher short-run house prices which are not in accordance with theory. The effect of increased interest rates becomes negative after five quarters. The result might be influenced by recent developments in the house market in Australia.

Figure 4.6 House prices and the policy interest rate in Australia



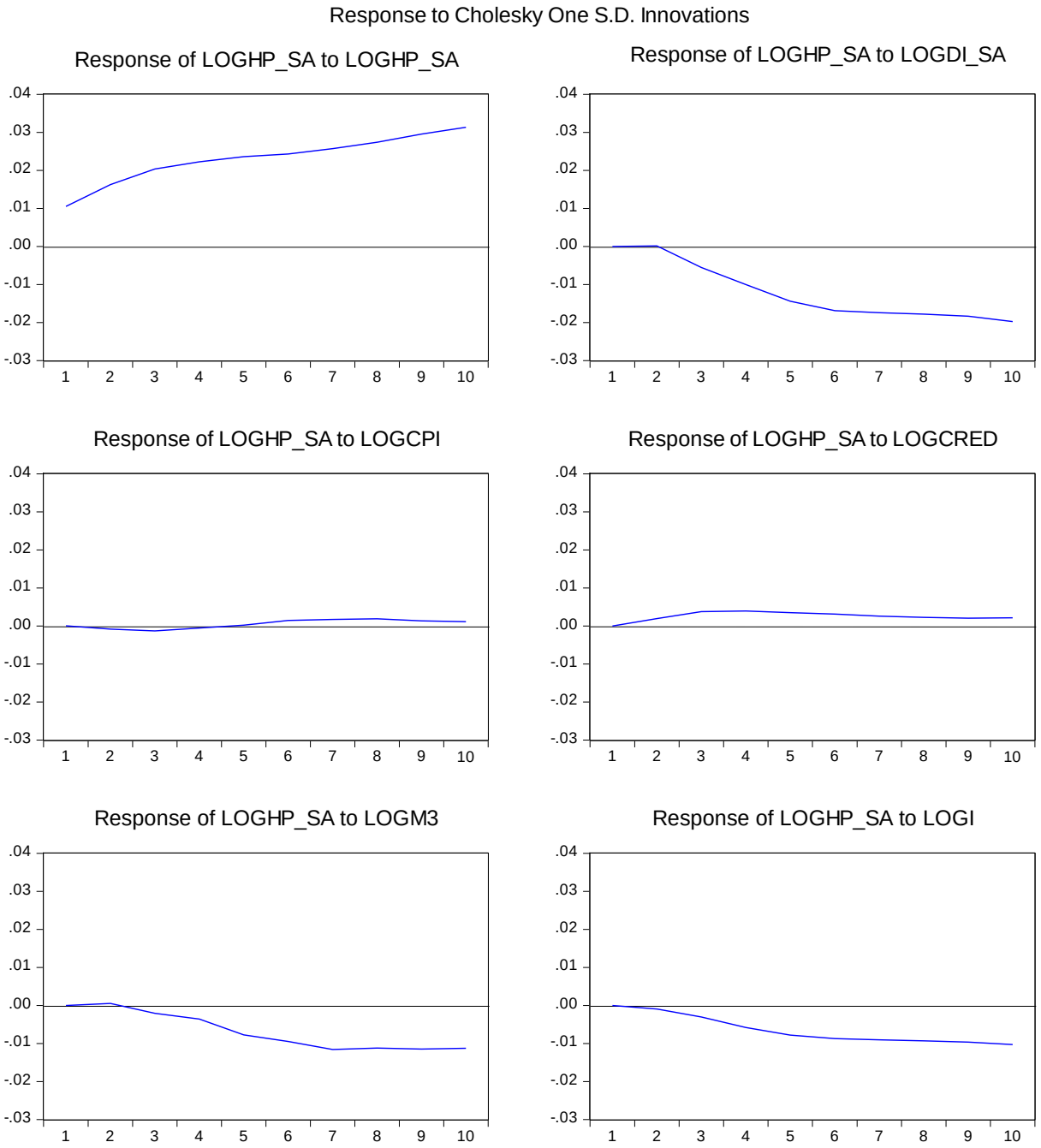
Source: Reuters EcoWin and IFS

The house prices in Australia have continued to rise soon after a short-run drop in 2008 and early 2009 due to the financial crisis (Australian Bureau of Statistics, Aug 2010). The Reserve Bank of Australia has undertaken the most rapid interest rate increase in 14 years during the last year. Yet house prices continue to rise. Despite the short-run positive effect of an increasing policy interest rate on house prices it is safe to say that in the long-run a rise in the interest rate does cause house prices to decrease.

Sweden

The data ranges from Q1 1993 to Q1 2010 and gives 3 cointegrating relationships. The impulse and response outcome can be seen below.

Figure 4.7 Impulse response analysis for Sweden



Note: F-stat: 2.79, Adj. R^2: 0.47, LOGHP_SA and LOGDI_SA means that the house prices and disposable income are seasonally adjusted by using Eviews X12-ARIMA procedure.
Source: Reuters EcoWin, IFS and Statistics Sweden

The Swedish result of the impulse response test shows that shocks in current house prices pushes up future house prices and it is the variable that seems to affect house prices the most. Inflation does not seem to affect house prices and positive shocks to money supply and disposable income have negative effects on house prices. Figure 4.1 illustrates the annual growth of house prices and disposable income, here one can find many years where the growth rate of house prices was quicker

than the disposable income; hence the growth rate of house prices has increased faster than the disposable income. This can be explained by the way disposable income is calculated (see the section on New Zealand). If a household makes a profit on a house investment, disposable income decreases since taxes are levied on the profit. The profit after tax is then registered as increased wealth and not as increased disposable income. The tax levied on capital gains is 30 per cent in Sweden. Since house prices have increased quickly in Sweden since 1993 (see figure 4.10 below), the negative effect to increased disposable income on house prices might be explained by capital gains being subject to taxation.

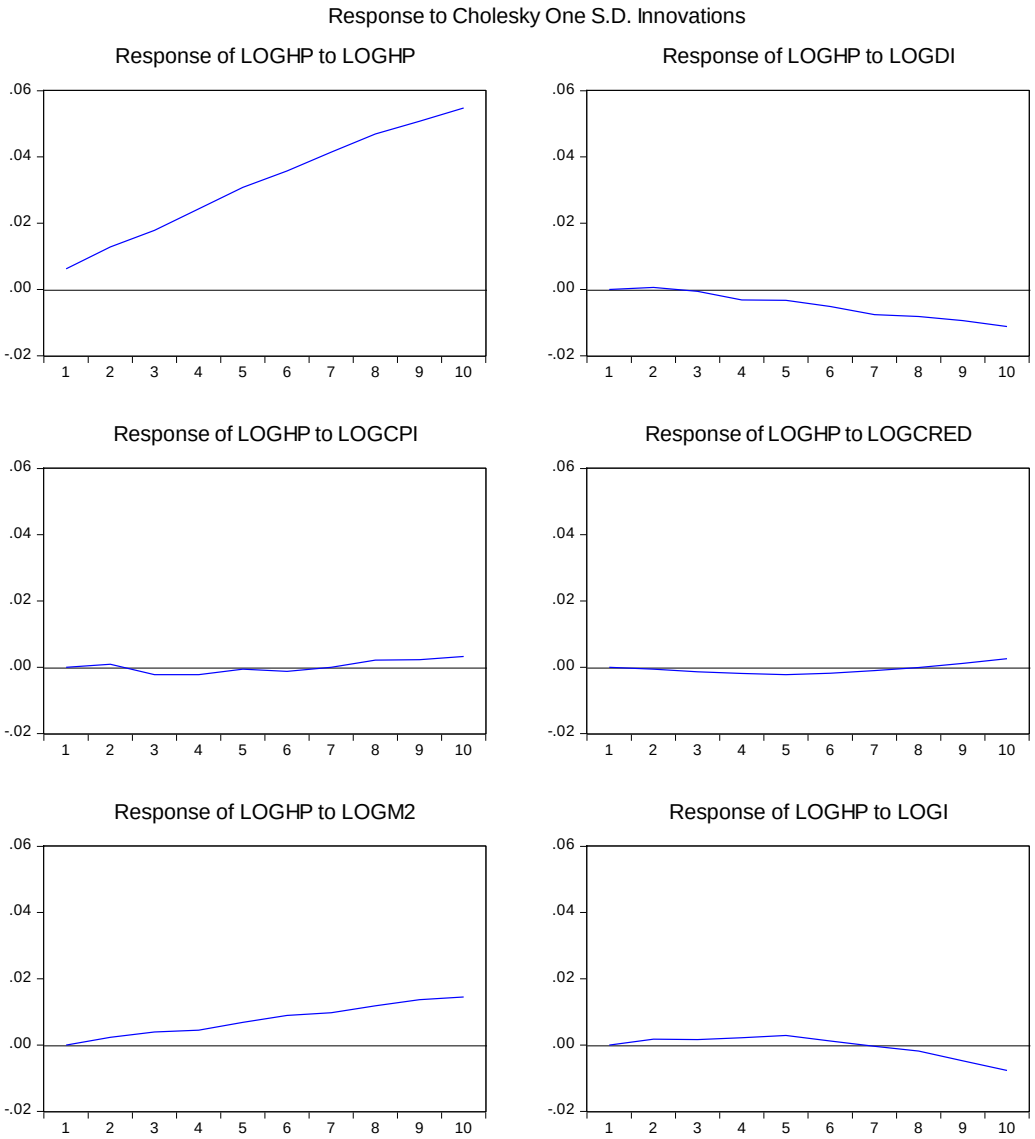
The weak response to increasing credit is a further unexpected result. Nevertheless, increased credit does affect house prices positively. The requirements on down payments have decreased considerably in Sweden. In 1997 the general level was 25 per cent and 11 years later households were granted loans on houses, paying only 10 per cent as down payment (Frisell and Yazdi, 2010).

Larger money supply, measured by M3, seems to lead to decreased house prices after 2 quarters. This may be a consequence of limitations of the model and the data. M3 grows considerably slower than house pries in Sweden during this time period and that might be the reason for this result. However the main result that we are interested in is shown in figure 4.7, i.e. by tightening monetary policy, the Riksbank can affect house prices negatively.

U.S.

The data ranges from Q4 1987 to Q4 2009 and gives 2 cointegrating relationships. The impulse and response outcome can be seen below.

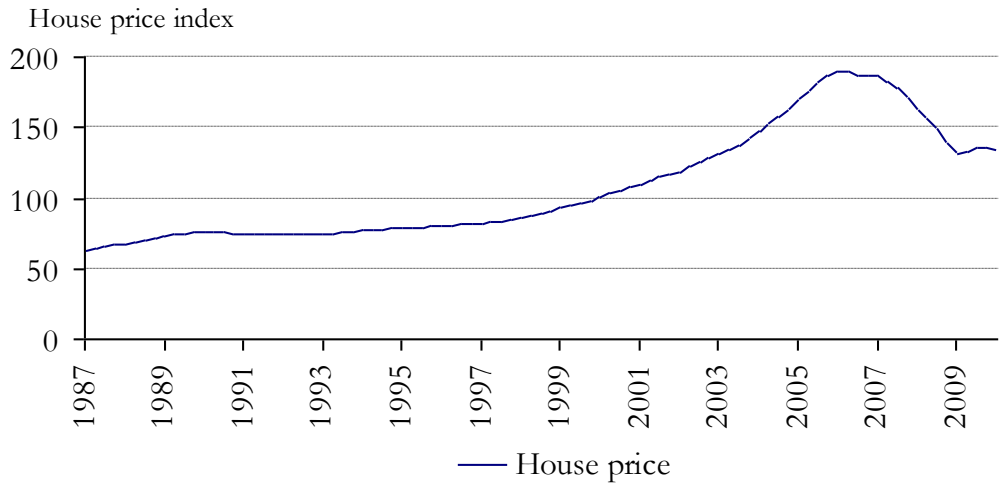
Figure 4.8 Impulse response analysis for the U.S.



Note: F-stat: 45.17, Adj. R^2: 0.88
Source: Reuters EcoWin, IFS and U.S. Federal Deposit Insurance Corporation

The strongest impulse from a shock among the different variables is previous house prices. Inflation and the amount of private credit do not seem to have any significant effect on house prices. Aggregate monetary supply on the other hand influences house prices positively. As can be seen in the impulse responses in many of the other countries, disposable income has a negative effect on house prices. The interest rate seems to have a slightly positive effect in the short-run. Looking at the graph presenting the response of house prices to a raised interest rate in Australia there are similarities, i.e. house prices have increased steadily over the last 23 years. The difference between the development in Australia and the U.S. is that prices increase linearly in Australia. In the U.S. houses prices practically explode in an almost exponential manner after 1997.

Figure 4.9 House price development in the U.S.



Source: Reuters EcoWin

However, after one and a half years the policy interest rate ends up having a negative impact on house prices.

4.4.1 CONCLUSION OF THE EMPIRICAL ESTIMATION

Mishkin (2007a) argues that it is difficult to estimate house prices by using econometric models. The econometric modelling above confirms this. The models are only able to produce estimates that explain around 50 per cent of the house price movement in the inflation targeting countries. The adjusted R^2 is significantly higher in the U.S. where 88 per cent of the estimators explain the variation of the house price development. The estimator that has a positive effect on house prices in all countries is lagged house prices. Changes in house prices will have a substantial effect on house prices in one to two years.

The second most significant estimator, that has a negative effect house prices, is the policy interest rate. By raising the interest rate the central banks can affect house prices in most countries. However it does seems more difficult to cool down house prices in the short-run in the U.S. and Australia. Here house prices respond positively to tightening monetary policy for one and a half years before they decrease as a result of the increased interest rate. Thereby, it is possible to state that increased policy interest rates do have negative effects on house prices in all countries studied above.

Shocks to the inflation level seem to decrease house prices in Australia, Canada and the UK. This result confirms the findings made by Iossifov et al. (2008). However, the outcome for New Zealand gives a conflicting depiction. An increasing inflation rate leads to higher house prices in New Zealand. This outcome can, however, be confirmed by Tsatsaronis and Zhu (2004) who find that increasing

inflation leads to growing house prices by employing cross-section analysis and using observations in 17 industrialised countries. Positive shocks to the inflation level do not seem to significantly influence house prices in the U.S. or Sweden.

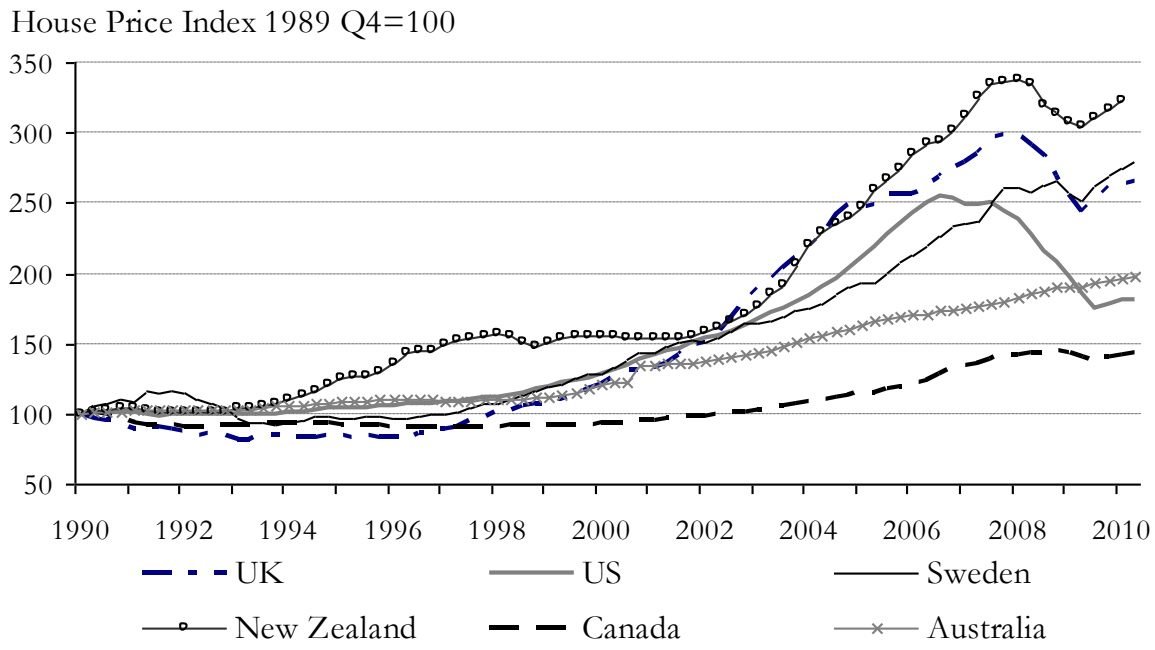
Increasing money supply leads to increasing house prices in New Zealand, Canada, Australia and the U.S which conforms to the empirical estimations assessed in Belke et al. (2010). However, in this study, positive money supply shocks do not seem to increase house prices in the UK where M4 has practically no influence on house prices at all. This can also be found in the result for Sweden. Increasing M3 in Sweden even appears to decrease house prices.

Another important determinant for house prices, in theory, is disposable income. This study finds that increasing disposable income raises house prices in the UK, Australia and Canada. Conversely the disposable income leads to declining house prices in New Zealand, Sweden and the U.S. This result can be compared with Tsatsaronis and Zhu (2004) who reach the conclusion that disposable income is a weak determinant of house prices. They also find that disposable income does not seem to be a particularly good determinant for house prices. However the confusing result in this study might have to do with the data problems which are explained in the section that analysis the results of the New Zealand and Swedish data.

After these empirical tests one is implied to agree with Taylor (2007 and 2009). Higher interest rates had probably been able to slow down the rapid growth of house prices and house starts.

When comparing the development of house prices by creating an index and setting the base year to Q4 1989 it is clear that house price development in the U.S. has not been the most explosive among the countries. Looking at figure 4.10 it is clear that New Zealand and the UK have experienced the most dramatic price increases over the last 10 years. Here the prices peaked in the 4th quarter of 2007 i.e. a year after they peaked in the U.S. Furthermore prices dropped for one and a half year before they started to pick up again. This pattern can be seen in Sweden as well; here prices reached their highest level in the 3rd quarter of 2008. The financial crisis made the prices fall for a short time period but they are currently growing again. In Australia, the crisis does not seem to have had an effect on house prices. The U.S's neighbour Canada has had the most moderate house price development among the countries.

Figure 4.10 House price development



Source: Reuters EcoWin

Investigating merely the house price development does not deliver any clues to why the fall in prices in the U.S. house market were able to trigger an international financial crisis, since they do not seem to have the most extreme development. Mishkin (2007a) writes that falling house prices can cause financial instability as in the Nordic countries in the beginning of the 1990's, but not a major financial crisis spanning around the world. However he argued that the quickly growing subprime market should be of concern for the policy makers already in 2007. Mishkin (1997) further explains that lending booms often occur when deregulation, liberalisation and financial innovation occur at the same time. Financial liberalisation began slowly in the 1980's only to increase more rapidly in the 1990's. The increasing financial openness continued to develop around the world and economists wrote articles on the "Great moderation". The great moderation is explained by Bean (2009, p.1) as a "*...period of unusually stable macroeconomic activity in advanced economies*." As this stability continued the participants in the market became less and less concerned with risk premiums which declined. In addition many central banks' ran a relatively loose monetary policy. The search for higher yield led to financial innovation. The innovations were complex financial instruments and the leverage was kept off the balance sheets in order to avoid on-balance capital charges (Been, 2009). It is clear that this was risky, but the downside risk seemed forgotten until house prices started to fall. The next section will therefore explore how these financial innovations worked and in what sense they contributed to the global financial crisis.

4.5 THE SUBPRIME CRISIS- THE WILD WEST IN THE FINANCIAL MARKETS

During the past 30 years economies across the globe have experienced ever lower interest rates in combination with deregulation of the financial markets. This allowed for increased financial innovation. The emerging subprime crisis during the summer of 2007 triggered a financial crisis that threatened to derail the entire global financial system. How could the U.S. subprime market with a size of approximately $1.2 trillion in 2007 which only corresponds to 6 per cent of the U.S. traditional banking system[37] cause a financial crisis that spanned around the globe?

4.5.1 MECHANICS OF THE U.S. MORTGAGE MARKET AND SUBPRIME MARKET

The U.S. government has a long history of promoting home ownership and has been very generous with granting home owners tax benefits. For example home owners are able to make tax deductions for interest paid on mortgages and property taxes on the federal and state income taxes. Moreover, gains realised from any property sale are exempt from taxes according to some prerequisites.

In 1938 after the great depression, the U.S. congress established government agency lenders that should facilitate stability to the secondary mortgage market and provide enough capital to lenders in the primary mortgage market even under times of financial stress. The premier agency created was the Federal National Mortgage Association (Fannie Mae) which should make sure that there were enough funds to fund mortgage lending to prime borrowers (individuals with top-credit-quality). In addition, agencies like the Federal Housing Administration (FHA) and Veterans Administration (VA) which should provide funding as exceptional lenders to individuals with moderate incomes and veterans were created. In 1968 the U.S. congress restructured the mortgage market by privatising Fannie Mae and creating the Government National Mortgage Association (Ginnie Mae) as a government owned corporation. This enabled the funding for borrowers that failed to qualify for loans that could be sold to Fannie Mae[38]. Two years later the congress established the Federal Home Loan Mortgage Corporation (Freddie Mac) as a shareholder-owned company pursuing similar goals as Fannie Mae and providing some competition for Fannie Mae. Both entities were run as

[37] According to Gorton (2010).

[38]The government sponsored enterprises (Fannie Mae and Freddie Mac) do not originate loans to borrowers directly. They purchase pools of loans from lenders i.e. commercial banks and finance corporations. Ginnie Mae is the only mortgage agency that is backed by the full faith and credit guarantee of the U.S. government.

Government Sponsored Enterprises (GSE's), which meant that they were not explicitly backed by the full faith and credit guarantee of the U.S. government, nevertheless, they had strong ties to the government as the President himself appoints members to the Freddie Mac and Fannie Mae boards. Both institutions have a line of credit with the U.S. Treasury and most investors considered debt securities issued by both institutions to carry an implicit guarantee by the U.S. government. Over all the creation of these agencies and corporations has led to massive growth in mortgage financing, lower mortgage rates, increased liquidity and standardisation of documentation and processes in the industry, over time (Citigroup, 2005).

Due to the turmoil in financial markets and in particular the U.S. mortgage market during 2007 and 2008, the U.S. government had to put both Fannie Mae and Freddie Mac under conservatorship of the Federal Housing Finance Agency (FHFA) in September 2008. Investors began to demand higher spread premiums on securities issued by Fannie Mae and Freddie Mac and this was endangering the mission of providing affordable funding to U.S. homeowners. The U.S. government committed itself to provide additional capital, when needed, for both institutions in the light of their material importance to the U.S. economy, as both GSE's guaranteed $5.4 trillion of Mortgage Backed Securities which corresponds to the publicly held debt of the U.S. (FHFA, 2008). Until August 2010 the U.S. government had to provide both institutions with a total of $148.3 bn. (RBC, 2010) of additional capital.

The mortgage market is divided into a conforming part and a non-conforming part. The conforming mortgage loans are all the loans that qualify for sale to Fannie Mae and Freddie Mac due to the conforming loan limit sizes issued by the FHFA, which in 2010 correspond to $417 000 for a general single family home[39] (these are related to as "prime loans"). All loans that cannot be sold to Fannie Mae or Freddie Mac and that are not insured by the FHA or partially guaranteed by the VA are called non-conforming mortgage loans. The process for originating non-conforming mortgage loans is less standardised than the one for conforming mortgage loans. There are three types of non-conforming mortgage loans: i) Jumbo Prime loans, ii) Alternative-A loans (alt-A) and iii) Subprime loans (also called Home Equity Loans or HEL).

[39] According to FHFA's webpage, May 2011.

Table 4.2 Differentiation between U.S. mortgage categories[40]

	Prime	Jumbo	Alt-A	Subprime
LTV's (Loan-to-Value)	65-80%	65-80%	70-100%	60-100%
Borrower FICO	700+	700+	640-730	500-660
Credit History	Good	Good	Good	Poor
Conforming to Agency Criteria	Conforming	Conforming by all standards but size	Non-conforming due to documentation or LTV's	Non-conforming due to FICO, Credit History, documentation or LTV's

Source: Gorton (2009)

Jumbo Prime: are mortgage loans to prime borrowers, where the outstanding balance exceeds the conforming loan limits. Jumbo prime mortgage loans are predominantly issued in high-cost states, such as California. California often makes up for more than 50 per cent of jumbo prime mortgage loan pools. Jumbo prime loans are often issued in the form of Adjustable Rate Mortgages (ARM's[41]) and specifically as interest only- and option ARM's (Citigroup, 2005).

Alt-A: are mortgages given to borrowers that are unable or unwilling to provide the documentation required in order to qualify for a prime loan which could have been sold to Fannie Mae or Freddie Mac. However the credit history of Alt-A borrowers has historically been strong. Moreover, Alt-A loan balances, debt-to-income ratios, and the proportion of investor properties are usually higher than those of prime loans. In addition the proportion of single-family properties is commonly lower than for prime loans. For the benefit of not having to provide as detailed documentation, the borrower has historically paid approximately 0.5 per cent more in interest than on comparable prime loans (Citigroup, 2005).

Subprime/HEL: the subprime category includes a few different subcategories of mortgages (such as subprime first lien, subprime second lien, High Loan to Value (HLTV) loans, reperforming loans and program exception loans[42]). The largest subcategory which makes up for about 80 per cent of

[40] FICO is a credit score created by Fair Isaac & Company (http://www.fairisaac.com/fic/en). The scores range between 300 and 850 and the higher the score the higher the chance of repayment. LTV's in Non-conforming loans can actually range up to 125 per cent if the borrower takes out a 2nd Lien mortgage as well.

[41] See explanation on p. 119.

[42] When lenders issue loans to borrowers, they usually require that collateral is made against the principal of the loans in order to assure future repayment of the principal in case the borrower defaults. Second Lien loans are pledged to the same collateral as First Lien loans, but Second lien lenders rights to collect proceeds from the same collateral rank behind First Lien lenders rights to collect proceeds from the very same collateral.

subprime loans is the subprime first lien category, where we find borrowers with impaired credit histories but that still can put in 20-25 per cent equity in the property and with repayment periods for up to 30 years. This category is usually the one referred to when the media relates to subprime mortgages. Subprime second lien loans rank junior to the first lien loans and are often granted in combination with the first lien loans in order to reduce the equity portion in the first lien loan. They are used by households to finance credit card debt, student loans or home improvements. These kinds of loans are also taken out by prime borrowers and the category represents approximately 10 per cent of the overall subprime market. HLTV-loans can be made as both first and second lien loans and can represent up to 125 per cent of the property's value. First lien HLTV's usually represent 102-103 per cent of the property's value and are generally taken out to avoid the down payment. Second lien HLTV's usually represent 110-115 per cent of the property's value and the part that exceeds the property value is some kind of consumption related loan. The reperforming- and exception loans category represent loans that in one way or the other have been in delinquency, default or modified/restructured along the way (Citigroup, 2005).

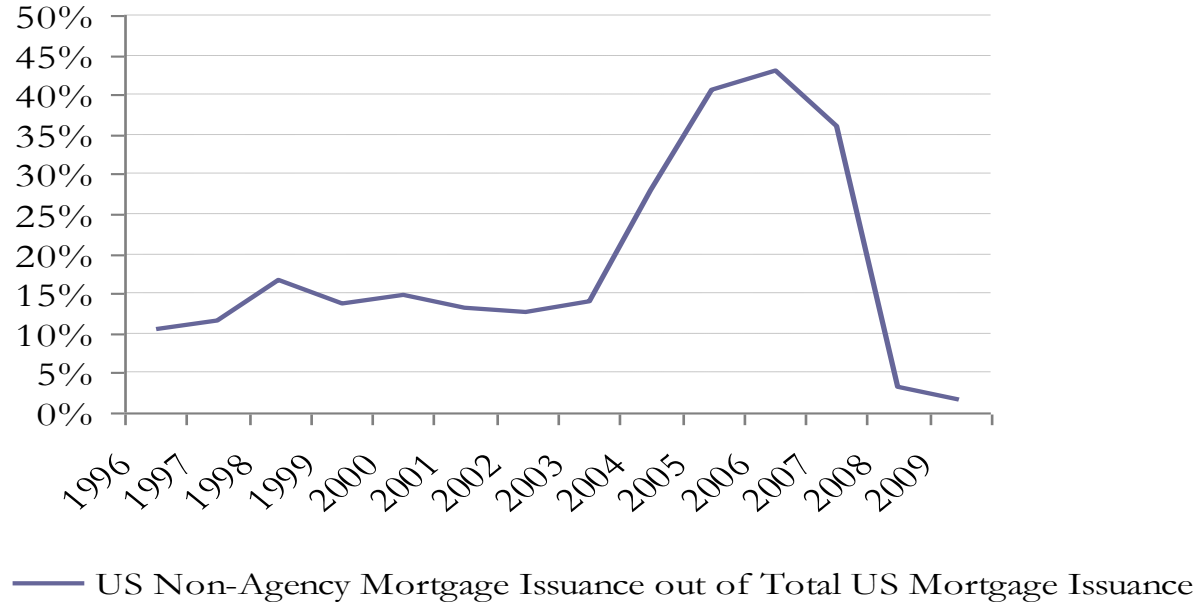
Immense rise in subprime volume

As easily can be seen from the above text, mortgages issued in the non-conforming market, carry a significantly higher credit risk than those issued in the conforming mortgage market. A subprime borrower is defined by the following characteristics:

- They only have limited or no documentation
- Their credit history is impaired
- Often have second lien mortgages taken on top of the first lien mortgage and HLTV-loans that significantly exceed the value of the property.

Historically the issuance of non-conforming mortgages had made up 10-15 per cent of the U.S. overall mortgage market, but in the time period 2004-2007 issuance exploded and in 2007 almost became as large as the entire prime mortgage issuance (see figure below).

Figure 4.11 U.S. Non-agency mortgage issuance



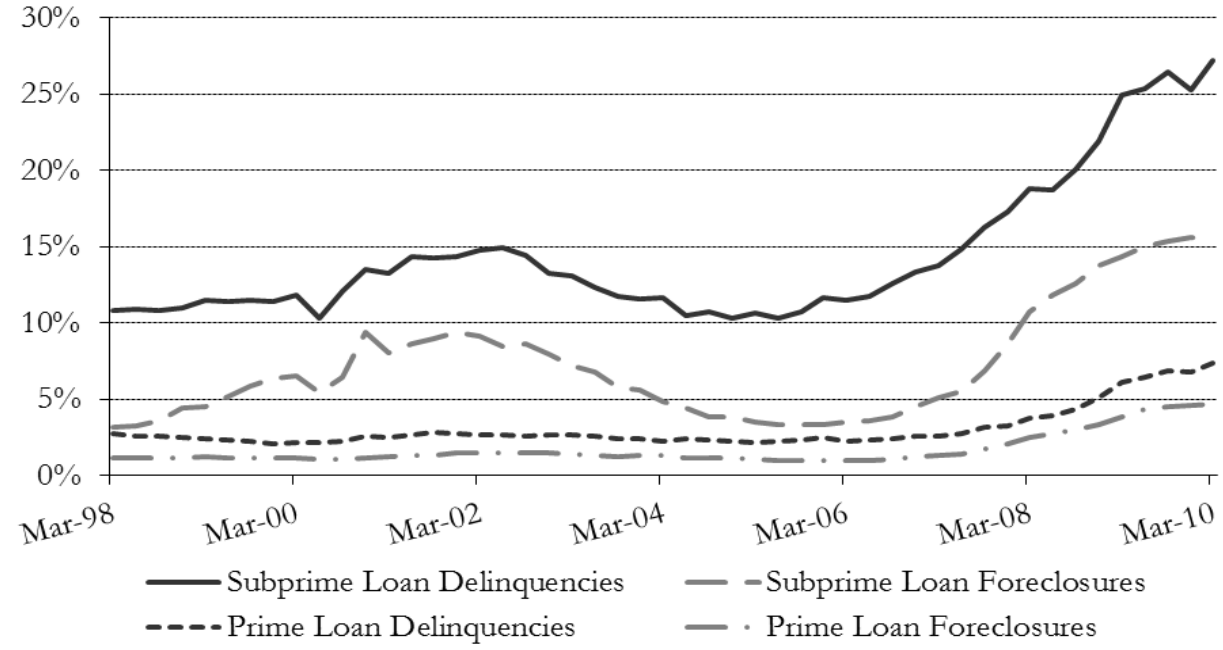
Source: Securities Industry and Financial Markets Association (SIFMA)

The vast increase in non-conforming mortgage issuance seen in the figure above was mainly driven by ever increasing profit targets at mortgage originators. Managers at mortgage firms became more and more used to extremely low mortgage losses (even under systematic risk events) due to a long period of low default rates, strong economic growth, and a prolonged phase of loose mortgage underwriting standards by banks (Rossi, 2010).

In the time period between 2003 and 2007 mortgage originators were able to enhance their profitability and attractiveness to investors significantly by increasing their issuance of non-conforming mortgages. At the same time they reduced their share of prime mortgage issuance. This was possible since regulatory capital requirements were the same for both products, however, the interest rate charged on non-conforming mortgages was much higher. If they instead had used appropriate estimates for the economic capital[43], which would have monitored the potential losses more adequately for the different products, managers most likely would not have promoted the rapid increase in non-conforming loans in the same way according to Rossi (2010).

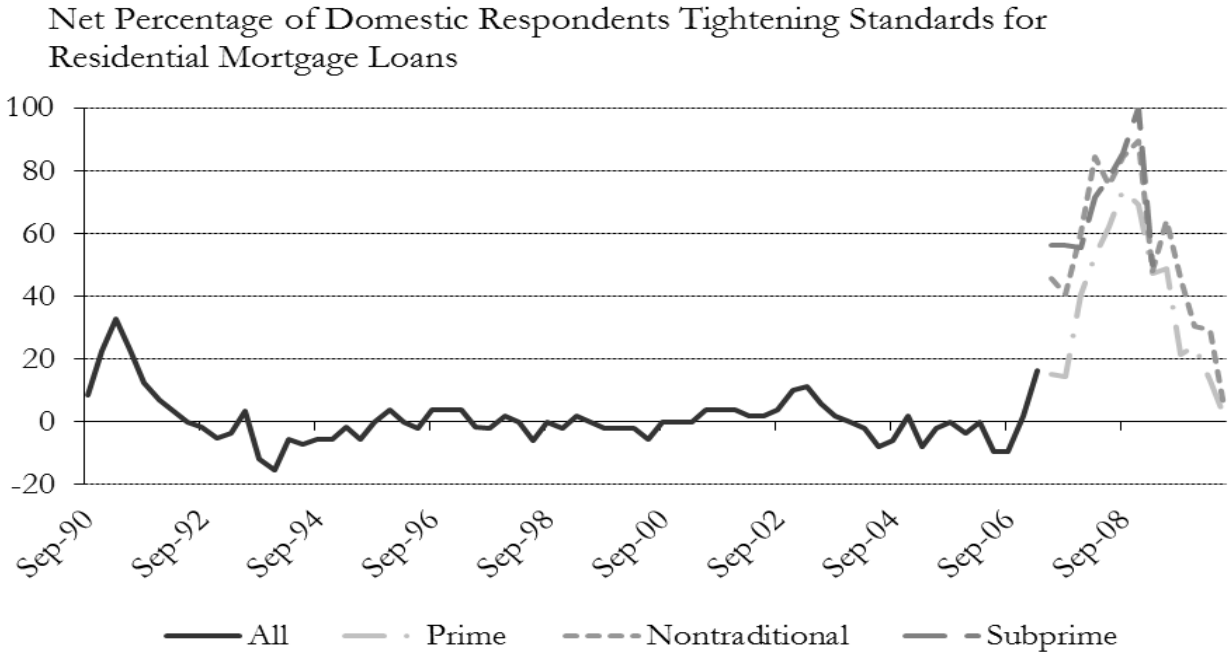
[43] To estimate economic capital they would have needed to build credit loss distributions on historic mortgage performance and forecasts of unexpected losses.

Figure 4.12 Delinquency and foreclosure on U.S. mortgage loans



Source: Bloomberg

Figure 4.13 Senior loan officer survey, tightening of underwriting standards

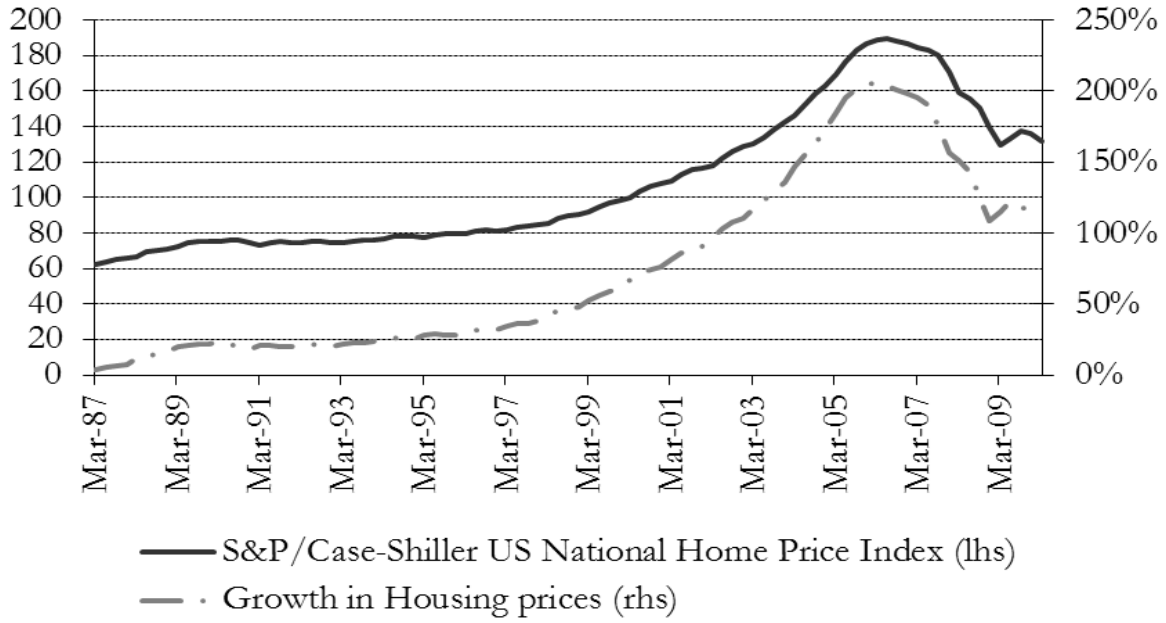


Source: Federal Reserve Board

From both figure 4.12 on the Delinquency and foreclosure rates and figure 4.13 on the Loan Officer Survey one can see that it is very likely that the long time period of low foreclosure rates i.e. before

2007, persuaded many managers at mortgage firms to assume that these low rates had come to stay and that they also directed senior bankers to believe that there was no need to raise underwriting standards, as that would only lead to a loss of business to competitors. In addition the Bush administration aggressively promoted its agenda of giving every American the opportunity to own their own home, while keeping government regulation of the financial industry at a minimum (Becker, Labaton and Stolberg, 2008). This answers why the volume of non-conforming mortgages increased so rapidly in the years 2004 to 2007, but to see why the fall in house prices[44] became so severe as can be seen in figure 4.14 below. With home prices dropping more than 30 per cent from their mid-2006 highs, one has to examine how the mechanics of subprime loans actually work.

Figure 4. 14 House price movements in the U.S.



Source: Bloomberg

4.5.2 KEY FEATURES OF SUBPRIME MORTGAGES AND SUBPRIME DELINQUENCY

The driving features of subprime loans which gave a group of borrowers the opportunity to borrow who, under normal circumstances, never would have been granted a loan, are two folded: i) a reliance on ever increasing house prices and ii) a stable and low interest rate environment.

[44] It was the largest since the Great Depression of the 1930s' (Gorton, 2009).

Where i) facilitated the lending to much riskier borrowers by assuming that house prices would continue to rise over time and that the subprime borrower could refinance his loan in short time intervals while the price increase of the property would have created equity for him in the meantime. And ii) the low interest environment pushed investors in the financial markets to search for pockets of yield in an environment of continuously declining yields.

The major part of subprime mortgages was made up of ARM's, with structures known as 2/28 or 3/27. Both mortgages are typically amortised over a 30 year period. In a "2/28 ARM" the interest payments are fixed rate payments during the first two years (represented by "2"). During the remaining time period the interest rate turns into a floating interest rate (represented by "28"). A "3/27 ARM" works in the same way but with different maturities[45].

The fixed interest rate during the first 2 or 3 years was usually much lower, than the prospective reset rate which kicked in as the loans became floating rate loans. These rates are often referred to as "teaser rates" and were one of the reasons why subprime lending developed into "predatory lending"[46]. Because what most borrowers did not understand was that basically it was the lender that decided if the loan was refinanced at the end of the first period or not, depending on the economic benefit for the lender. Since approximately 80 per cent of subprime mortgages have prepayment penalties, it leaves the borrower with no option. Usually the refinancing would not end up in a regular long term fixed rate mortgage but sooner would be rolled over into another subprime loan. Sooner the idea is that the borrower refinances into a sequence of subprime loans as house prices rise and create equity while refinancing at ever lower interest rates. In the time period 1998 to 2006 this idea worked very well as house prices rose and interest rates declined and between 70-80 per cent of all subprime loans were refinanced (Ashcraft and Schuermann, 2008). The fall in house prices during the second half of 2006 signalled the starting point for what was going to cause the credit crisis beginning in the summer of 2007 during which mortgage lenders faced a wave of re-financings at higher interest rates which were going to force many borrowers into default due to the significantly lower credit quality of subprime borrowers. For as can be seen in the table below the non-conforming borrowers had become much more risky in the years right before the crisis with higher LTV's, a lower degree of full documentation provided, a higher proportion of prepayment penalties included and a significantly higher amount of second lien loans included in the financings. This line of reasoning is also supported by Demyanyk and Hemert (2009) which found in their study

[45] Subprime loans can take the form of interest-only, 40-year ARM's and subprime second liens.

[46] When the lender is attracted to borrow too much, he/she is lured to borrow by very low initial interest rates or is attracted to borrow through complex mortgages that he/she did not understand when entering into them – like these different kinds of subprime loans.

that the dramatic deterioration in credit quality for subprime borrowers could be monitored well in advance before the bubble burst in mid-2007.

Table 4.3 The increased riskiness of non-confirming loans

	Avg. LTV	Full Documentation Provided	No Prepayment penalty included	Second Lien Mortgage
Alt-A Mortgages				
1999	77.5	38.4	79.4	0.1
2000	80.2	35.4	79	0.2
2001	77.7	34.8	78.8	1.4
2002	76.5	36	70.1	2.4
2003	74.9	33	71.2	12.4
2004	79.5	32.4	64.8	28.6
2005	79	27.4	56.9	32.4
2006	80.6	16.4	47.9	38.9
Subprime Mortgages				
1999	78.8	68.7	28.7	0.5
2000	79.5	73.4	25.4	1.3
2001	80.3	71.5	21	2.8
2002	80.7	65.9	20.3	2.9
2003	82.4	63.9	23.2	7.3
2004	83.9	62.2	24.6	15.8
2005	85.3	58.3	26.8	24.6
2006	85.5	57.7	28.9	27.5
All numbers are in percentage points				

Source: Ashcraft and Schuermann, 2008

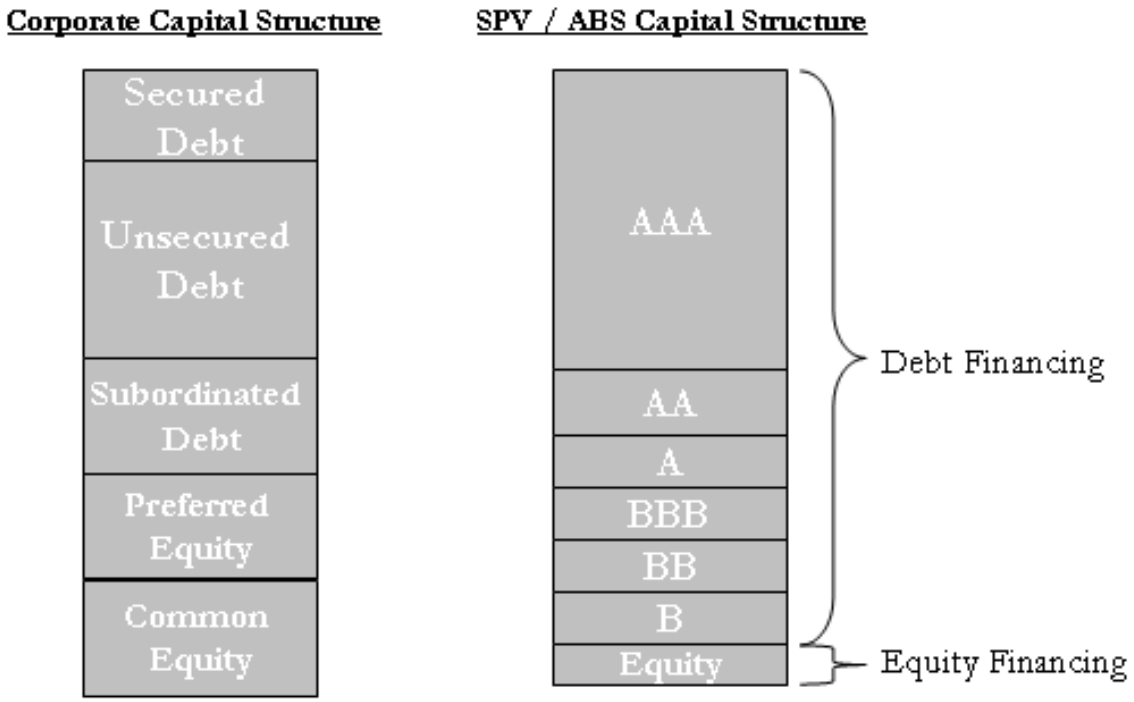
As is argued by Kiff and Mills (2007) and Deng, Gabriel and Sanders (2010), another even more predominant reason for the rapid fall in real estate prices, was the enormous growth of the securitization market and particularly securitization of Subprime Mortgages into Mortgage Backed Securities (MBS), Asset Backed Securities (ABS), and Collateralized Debt Obligations (CDO's) which will be explored in the next section.

4.5.3 SPREADING THE EFFECTS OF SUBPRIME DELINQUENCIES

Basically all ABS are created through the construction of a Special Purpose Vehicle (SPV), which essentially is an off balance sheet corporation that has neither employees nor a physical location (Gorton and Souleles, 2005) and (Bruyere et al. 2006). It only exists for one purpose, to buy certain

assets from a bank or another corporation. The capital structure of an SPV is very much the same as that of a corporation.

Figure 4.15 Comparison of a corporate capital structure and a SPV capital structure



Source: Morgan Stanley (2006)

For prime securitizations a MBS is created out of a pool of thousands of individual mortgages and most agency MBS are created as pass-through securities[47]. Any prepaid principal on the mortgages in the underlying collateral pool will be used to prepay the outstanding amount of senior tranches (see figure 4.16 below) in the MBS structure in the premier years[48] of the transaction (also referred to as sequential amortization, from the top to the bottom of the structure) while mezzanine[49] and equity tranches are not entitled to any cash flows from prepayments (this is referred to as "lock out"), but

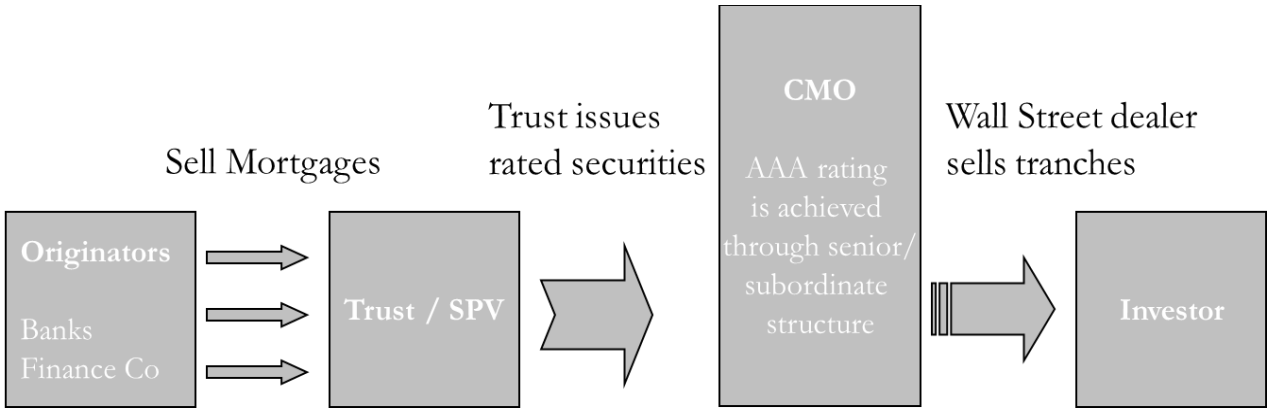
[47] In a pass-through security the monthly cash flows (principal and interest) which arise during this month are passed on to the investors in the MBS with deductions for fees charged by the originator of the MBS deal (Fabozzi, 2000).

[48] Usually the "lock out" period for subordinate tranches in their access to principal payments is three years (JP Morgan, 2009).

[49] Mezzanine tranches refer to those tranches generally rated A, BBB, BB and B, while senior tranches in most cases refer to those rated AAA and AA. In some cases the AA tranches have more of a mezzanine character due to the structure of the transaction.

will rather absorb any potential losses that appear in the underlying mortgage pool. This will cause the senior bonds to be paid down first and thereby increasing the percentage of collateral available to cover for the mezzanine bonds and equity. In prime securitizations where the bulk of the mortgages consist of ARM's the length of the lock out can be reduced if certain performance tests are satisfied, see Gorton (2008) for a brief description of these tests. When these tests are satisfied the prepaid principal allocation switches from sequential pay to pro rata pay. In general there is no over-collateralization in prime MBS deals and the equity tranche therefore absorbs the very first dollar of loss in the underlying mortgages that arises (therefore this tranche is also referred to as the first loss piece).

Figure 4.16 Securitization of non-agency mortgages[50]



Source: JP Morgan (2009)

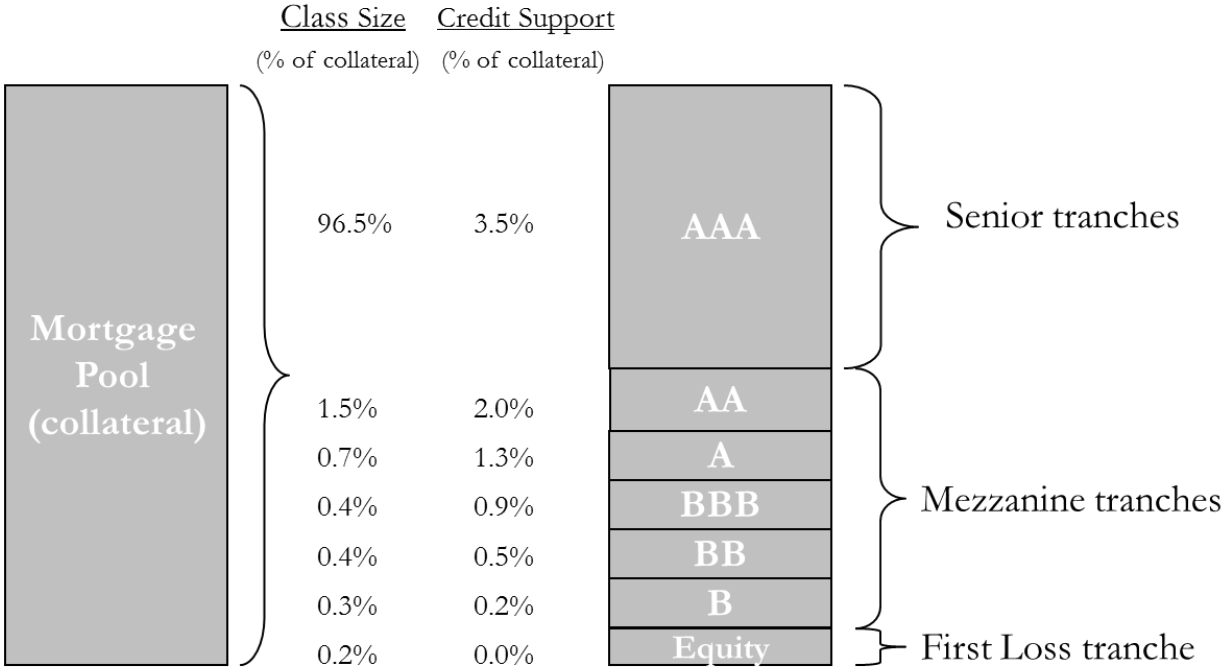
The process for setting up securitization vehicles is illustrated in the above figure and works in a similar way whether the underlying collateral pool consists of mortgages, bonds, leveraged loans, auto loans or student loans. Differences do however arise in the various types of securitization structures such as ABS, CDO, CLO and CDO squared. Subprime MBS transactions are much more complex in their structure than prime transactions. The main difference relates to the existence of overcollateralization (OC)[51] in the subprime deals, which can either be created through excess

[50] An SPV is an off balance sheet vehicle to which a bank can sell assets and collectively receive an AAA rating for these assets, that on a "stand alone" basis never would have been rated AAA (Fabozzi, 2000). A Collateralized Mortgage Obligation (CMO) is an ABS created by the SPV in order to finance the purchase of the assets bought by the SPV.

[51] Overcollateralization means that a $500 million securitized transaction is backed by $520 million of collateral, giving the transaction a level of overcollateralization of 4 per cent.

spread[52] over time or is part of the deal right from the start through a higher nominal amount of the collateral than the outstanding value of the tranches issued. The major difference in subprime securitizations is that refinancing of subprime loans generates substantial cash flows to the individual deals, which enables amortization and build-up of OC. Furthermore refinancings are dependent on ever rising house prices and a low interest rate environment. Hereby the cash flows in subprime securitizations (and therefore the cash available to create OC and to absorb credit losses) are much more dependent on house prices than in prime securitizations. This gives us the direct link to why subprime securitizations deteriorated so quickly during the crisis and lead to further deterioration in other securitized products.

Figure 4.17 Example of a subprime mortgage securitization



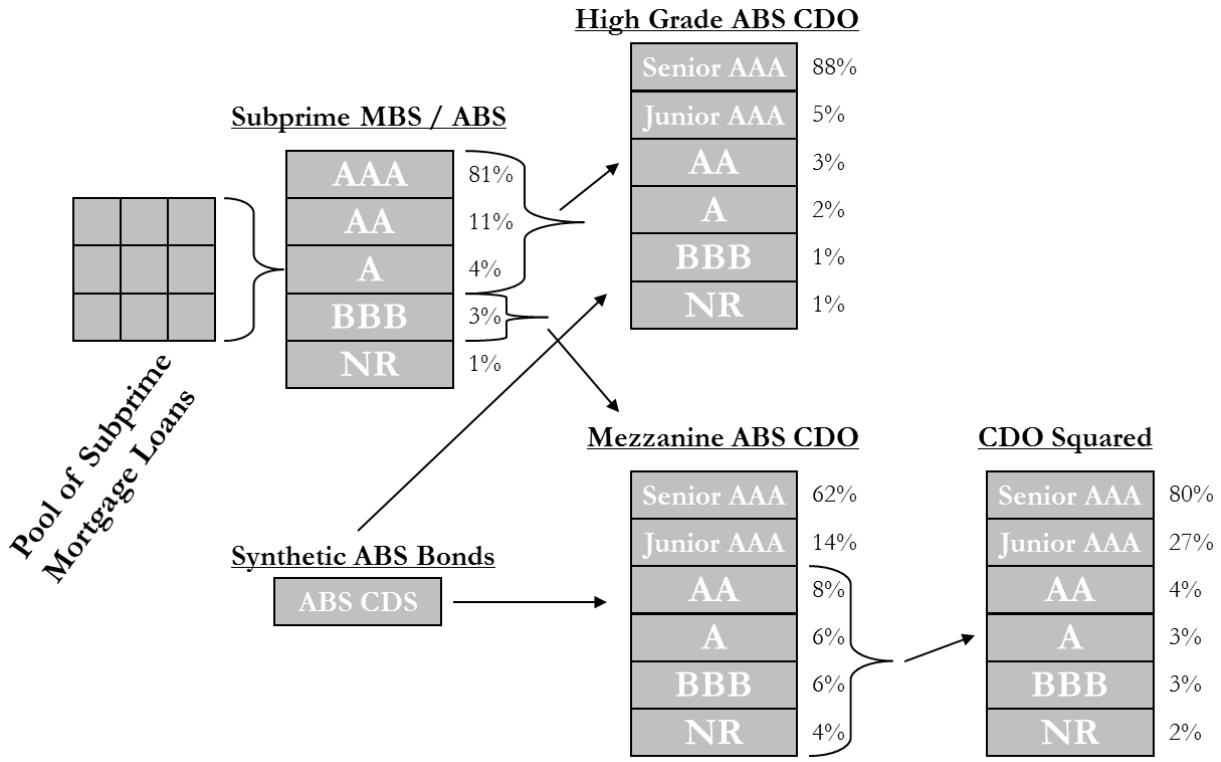
Source: JP Morgan (2009)

If this would have been it, then the situation would probably not have turned as severe as it did with a subprime crisis spreading into a credit crisis and then finally into a full blown financial crisis. But the wizards of financial engineering increased the leverage to the system even more by creating

[52] Excess spread (the cash flow left over from interest payments on the underlying collateral pool, after interest on the debt tranches in the securitization structure have been paid) is used to raise the OC through accelerating the pay down of the senior notes. When the OC target is satisfied together with other tests, excess spread can be directed towards other purposes, such as pay outs to the equity holders (Gorton, 2009).

CDO's out of MBS and ABS transactions that bought the BBB bond in 100 different MBS or ABS transactions. On top of this they even created CDO² (CDO squared) out of CDO's, as can be seen in the figure below. As investors kept searching for yield in the low yield environment before the crisis the market ended up in the situation that there were not enough ABS transactions outstanding to generate the collateral for setting up enough CDO's. In this situation, the financial engineers created synthetic ABS which are called ABS CDS[53] to form the collateral pools for CDO's and thereby multiplied the effects of the defaults in the subprime mortgage market as the synthetic part of the collateral pools widely exceeded the part that was made up of actual cash ABS transactions (Crouhy, Jarrow and Turnbull, 2008).

Figure 4.18 Wizards of financial engineering[54]



Source: UBS (2007) and Crouhy et al. (2008)

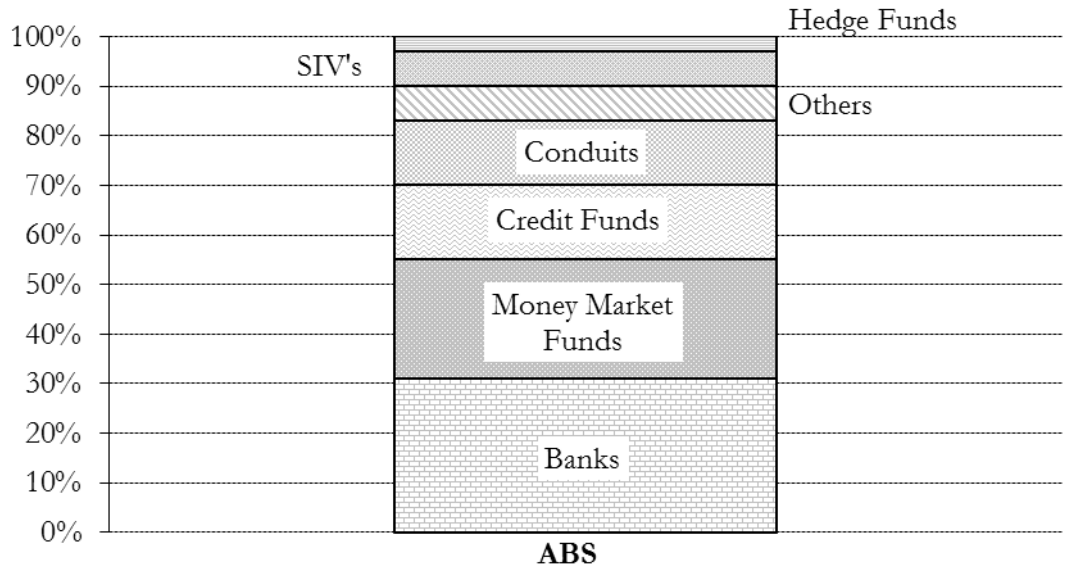
Another important reason for the rapid decline in asset prices was that all types of investors had invested in the securitized products. However, banks had the largest exposure to securitizations, which might seem odd considering that the reason for creating off balance sheet vehicles was to

[53] ABS Credit Default Swap (CDS) is a CDS, which protects the purchaser of the contract against default of the referenced asset. The seller of the CDS has to cover the loss in case of an event of default.

[54] NR in this case stands for "Not Rated" and represents the first loss tranche.

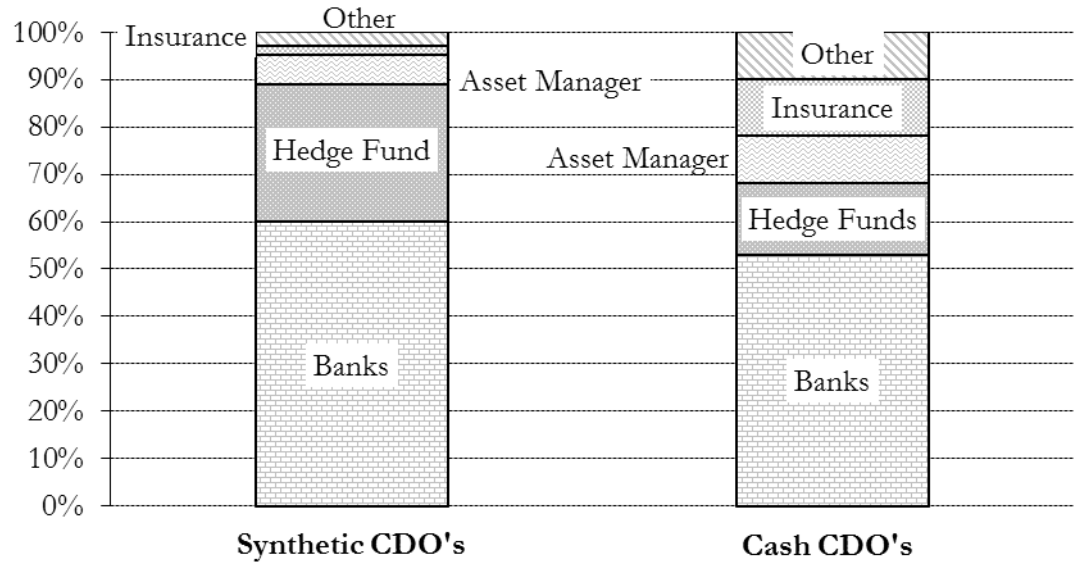
transfer risk to investors that better could absorb potential losses and share the risk. We can see below that banks held approximately 1/3 of all AAA ABS assets and significantly more than 50 per cent of all AAA CDO assets.

Figure 4.19 Buyers of AAA ABS



Source: Citigroup (2008a)

Figure 4.20 Buyers of AAA CDO's



Source: Citigroup (2008a)

Instead of diversifying risks among investors, which was the primary aim, banks managed to concentrate them within the banking sector. Banks used securitizations in order to boost their balance sheets and to speed up the growth of assets and thereby their own growth of profits. They increased their leverage by increasing their borrowing from creditors outside the banking system and used this money to increase the credit supply to the ultimate borrowers (in this case subprime borrowers) through securitizations. In addition banks then used their enlarged balance sheets to buy each other's ABS and CDO securities, essentially with borrowed money. The reason for the fatal impact of the subprime crisis was merely the heavy concentration of securitized risks on banks' balance sheets, which turned into both a credit crisis and financial crisis (Adrian and Song Shin, 2009).

4.5.4 LIQUIDITY FEARS CAUSE PULLBACK FROM LENDING - A FULL BLOWN FINANCIAL CRISIS WAS ON THE CARDS

When prices on subprime housing started to decline more rapidly and defaults on subprime mortgages continued to rise during 2008, it created widespread fear among banks and a deep mistrust in the individual bank's exposure to the concentration risks of securitized products. Since all banks were aware of the fact that they had bought and sold these securities heavily to each other over the preceding years in order to expand their businesses. But now no one knew exactly how much exposure there was "on the other banks" balance sheets (Taylor and Williams, 2009). The situation turned even more severe as many banks had become accustomed to a banking model where they borrowed money short term at very low rates and then again lent money more long term at higher rates. This model had worked very well during the years before the crisis but as short term concerns over banks' exposure towards securitized products increased, interest rates at the short end increased rapidly and reached levels well above those paid for longer term lending. This put banks in a difficult position as they risked running out of short term funding. The banks that relied most heavily on this kind of short term funding were the U.S. investment banks (Lehman Brothers, Bear Stearns, Merrill Lynch, Morgan Stanley and Goldman Sachs) and it was this liquidity crunch that forced Lehman Brothers into bankruptcy and Bear Stearns and Merrill Lynch to be taken over by JP Morgan and Bank of America.

So what is the connection between the decline of the subprime market, bank lending, bank funding and the dramatic decline of house prices and virtually all assets during the crisis. The explanation lies again to find in the so called "shadow banking system" where banks sold their loans in securitizations in order to generate larger profits than they would otherwise have been able to generated if they had kept them on their balance sheets.

In addition to this banks were the largest buyers of these assets for one reason: they needed to hold large amounts of AAA assets as collateral in order to guarantee for their short term borrowing in the repo market[55]. During the past 30 years securitized assets were the most widely used collateral in the repo market as there simply were not enough treasury bonds and highly rated corporate bonds to satisfy the repo market's demand. Gorton (2010) estimates that the repo market amounted to $12 trillion. However no one really knows the size of the repo market, but according to Citigroup (2008a) the investment banks (Lehman Brothers, Bear Stearns, Merrill Lynch, Morgan Stanley and Goldman Sachs) alone had around $5.1 trillion of repo agreements outstanding. As the concerns about the value of securitized assets started to grow repo counterparties (from the example in the footnote i.e. corporation X) demanded haircuts[56] on the collateral provided. Haircuts can be compared with a withdrawal of money from the bank that needs to be financed from the footnote we can see that the bank in this example would have had to come up with another $90 million to finance the haircut. Before the crisis haircuts were close to zero but as the table below shows they increased dramatically and as the research of Gorton and Metrick (2010) shows that haircuts for subprime related securitizations went to 100 per cent in late 2008 and early 2009 while those for the average securitization went to 45 per cent in the same period.

[55] A repo transaction basically works in the following way: a corporation X has $300 million in cash that it will use for some kind of project quite soon but not right now, as there is no deposit guarantee for these kinds of amounts on a regular checking account, the corporation X goes to the repo market (where virtually all banks are active) to deposit this money short term and earn some interest. The corporation X approaches Merrill Lynch and deposits the $300 million overnight. Merrill Lynch pays corporation X 2 per cent interest and has effectively borrowed $300 million To secure that corporation X will receive its $300 million the next day even if Merrill Lynch was to go bankrupt, Merrill Lynch puts up AAA ABS securities on which it earns Libor plus 4 per cent as collateral with a market value of $300 million which is physically transferred to corporation X and which corporation X could sell in case Merrill Lynch would default. Merrill Lynch hereby makes a profit as it borrows at 2 per cent and lends at 4 per cent.

[56] A haircut on repo collateral is usually required due to the liquidity or quality of the assets provided and works in the following way: If Merrill Lynch provided corporation X with AAA ABS CDO bonds for their $300 million in cash and corporation X would require a haircut of 30 per cent, this would mean that Merrill Lynch would have to provide corporation X with $390 million of the collateral.

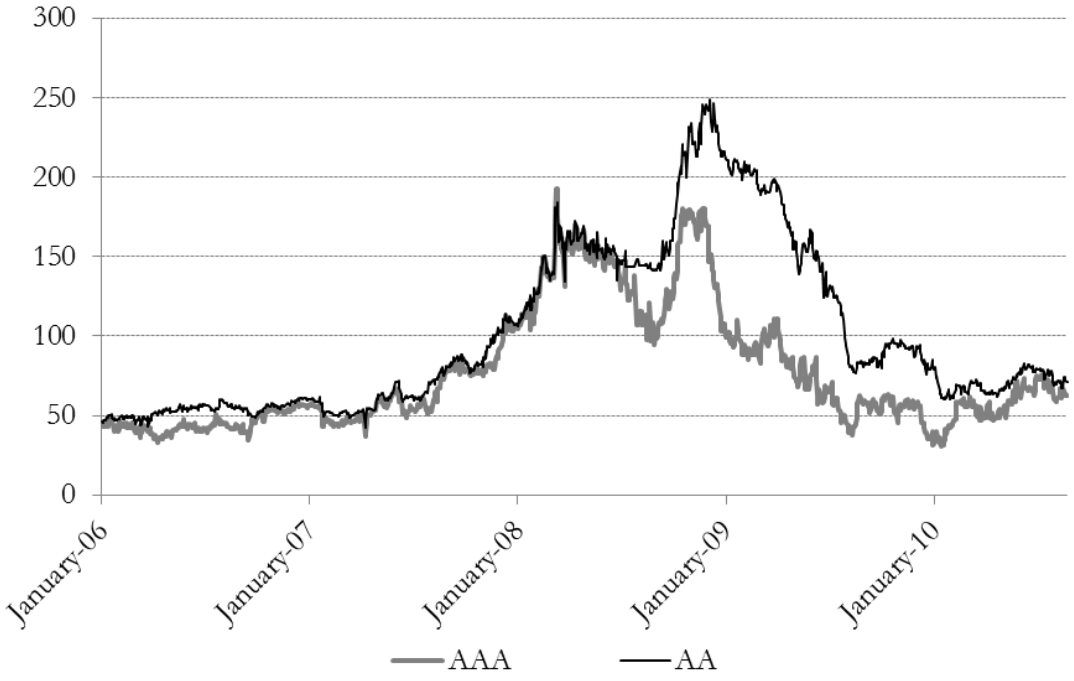
Table 4.4 Typical haircuts by asset class

Asset Class	Mar-07	Mar-08
AA Corp Bond	3%	12%
BB Lev Loan	20%	35%
BB HY Bond	15%	40%
Equities	15%	20%
Inv Grade CDS	1%	5%
AAA ABS CDO	4%	n/a
AAA CLO	4%	20%
AAA RMBS	2%	20%

Source: Citigroup (2008b)

The average haircut rose from near zero before the crisis to somewhere between 20-45 per cent. This represents an astronomical figure (recalling that the repo market amounted to $12 trillion) that banks needed to come up with in additional funding and the only way for them to achieve this was by selling off other assets that had not been so widely affected by the crisis, yet. When banks started to sell large amounts of these safer assets to generate funds this created massive downward pressure on these assets which can be seen in the chart below for AAA and AA rated corporate bonds.

Figure 4.21 AAA and AA U.S. corporate bond spreads



Source: Bloomberg

These effects basically transferred through to ever more assets in the financial markets and created the widespread asset price decline of the recent crisis. Furthermore, the securitized products had spread through the banking sector to many countries. It was not only banks in these countries that had invested in them, but even small local governments held these assets. Hence there was a snowball effect that, first led to asset prices falling, a credit crunch that affected corporations that were unable to finance themselves through new credits and the crisis thereby moved from the banking sector into the real economy, with central banks and governments pumping taxpayers' money into the system.

4.6 RESULTS

This analysis of house prices and the subprime market explains how, low interest rates and stable economic developments triggered financial innovations which ultimately lead to the financial crisis. The first part of this chapter shows that increasing interest rates do have negative effects on house prices. And that central banks, for example, the Federal Reserve Bank in the U.S. could have been able to dampen the house price bubble by raising the policy interest rate. Even though the burst of the house price bubble turned out to be the trigger of the crisis it is not possible to blame the financial crisis on low interest rates. It is, however, possible to claim that low interest rates spurred bankers that were eager to increase profits to act as financing wizards. Clever banking managers accompanied by under-regulation in the financial markets are probably more to blame for the financial crisis than anything else. How else could it be that borrowers with impaired credit history were granted subprime mortgages to buy houses at an interest rate that the borrowers would not be able to pay if rates were to increase? These mortgages were then securitized and sold as an ABS to investors. When the investors demanded more ABS's the banks created ABS CDO's which were sold to the investors. Hence the collateral i.e. the house was used as collateral by the borrower once and up to three times by the banks as ABS, ABS CDO and finally ABS CDO^2. One starts to wonder if no one considered the down-side risks. Aizenman (2009, p. 4) among other economists writes that

"Moral hazard arises when investors believe that they will be bailed out of bad investments by the taxpayers."

When banking institutions grow too big to fail the governments and central banks are forced to save them in times of crisis and this is a reason why regulation as well as independent central banks are essential (Aizenman, 2009). Aizenman (2009) argues just like Svensson (2010) that it does not have to be the central bank that sets the rules and controls that they are followed, but it has to be an independent institution with no biased interests. Even though Svensson says that it can be a task for

the central bank, it shall not influence the interest rate decisions. Hence monetary policy must not be used to control asset prices.

One can conclude that Taylor's (2007 and 2009) argument that interest rates were set too low and caused the house boom seem to be true as house prices in both inflation targeting and non-inflation targeting countries respond negatively to increasing interest rates.

However, the magnitude of the financial crisis was caused not by increasing house prices but by the wizards of finance that did not take risks into account i.e. they did not consider rising interest rates or falling house prices and there was no regulation that forced them to do so. This shows how important it is not only with regulation but also with economic models that take the financial market into account.

5 CONCLUSION

5.1 HAS INFLATION TARGETING LED TO IMPROVED PRIVATE SECTOR INTEREST RATE FORECASTS?

This thesis answers the question if inflation targeting has led to improved private sector policy interest rate forecasts. The empirical analysis asses how well interest rate futures can forecast the policy interest rate. The future interest rate is used as a proxy variable for the private sector's expected future interest rate. The outcome of the regression analysis shows that the private sector has become better at forecasting the central banks' policy interest rate in the UK and Sweden. In the other countries, i.e. New Zealand, Canada and Australia, rather the opposite is to be found.

Comparing the results from the inflation targeting countries with the non-inflation targeting countries shows that the private sector in the Eurozone is best at assessing the future policy interest rate. The forecast ability of the private sector in Japan is also very good, while the result from the U.S. estimation is rather poor considering that 30-day interest rate futures are used in the analysis of the U.S. Therefore it does not seem as if the private sector is better at predicting the future policy interest rate in the inflation targeting countries compared to the non-inflation targeting countries.

The poor result have different explanations; it might be that the transparency sometimes confuses the private sector. Even though the central banks publically reveal their objectives, forecasts and inflation targets they can still interpret the economic data differently from the private sector and thereby set a policy rate that comes as a surprise to the market. Although central banks are communicating their inflation target, their objective is to set a policy interest rate that will affect the inflation level in 1 to 2 years' time. Hence the inflation targeting central banks are actually performing inflation forecast targeting which means that they are setting a policy interest rate in order to control inflation that only can be forecasted. Another explanation might be negative and unforeseen economic chocks such as the September 11th attack on the World Trade Center and the Asian crisis which calls for extraordinary actions by the central banks. Even though these events did not occur in the inflation targeting countries they affected the international financial market and this may explain the poor results in 2001 and 1997-1998 in most of the countries.

A further explanation may be related to changing behaviour among the central banks. As an example, New Zealand's Reserve Bank introduced MCI as a policy instrument and an indicator for its interest rate decisions in 1997. Since MCI indicated an increase in the policy interest rate when the currency depreciated, the Reserve Bank of New Zealand increased the interest rate when the economy was struggling with the negative economic shock caused by the Asian crisis and a nationwide drought.

This was, of course, not the best remedy under the circumstances and the MCI was abandoned in 1999.

The predictability of the policy interest rate is overall surprisingly poor in the inflation targeting countries compared to the non-inflation targeting countries where one would expect the private sector to be worse at predicting the policy interest rate. The results reveal that the private sector has been best at predicting the interest rate in the Eurozone during the years 1999 to 2003 which is just after the Euro was introduced. However, between 2003 and 2008 the private sector's accuracy in predicting the actual policy rate decreased. One would expect the development to be the opposite, i.e. that the private sector would become better and better at forecasting the policy rate. But this study was not able to find reliable evidence to confirm that inflation targeting leads to better forecasts on the future policy interest rate.

The first part of the empirical analysis delivers a result that implies that transparency and communication has not helped the private sector to better predict the policy interest rate.

The second part of the empirical analysis investigates whether it is possible to find structural breaks in the estimator of the time series analysis. The tests were conducted by using the Chow breakpoint test and the CUSUM test. There seems to be great parameter instability in all the countries studied in this analysis. One reason might be that financial data is very volatile. However, the high number of structural breaks further strengthens the result found in the first part of the empirical analysis. It does not seem like the introduction of inflation targeting and transparency has improved the private sector's interest rate forecasts.

The structural breaks are significant almost each year in all of the countries, but the significance of the breaks decrease during some time periods. In Canada, Australia, the UK and Japan the significance of the breaks shrink over time. At the same time the private sector predictability of the interest rate improved in these countries. This implies that, as the estimator turned to become more stable, the interest rate became easier to forecast. However, this is not true in all cases. In Japan the breaks become less significant in 1999, while the private sector's interest rate forecast only improved three years later. This delay might be explained by the Bank of Japan's transparency and communication as well as the private sector's interpretation of the communication which the private sector probably had to learn how to interpret and trust.

The breaks in New Zealand are the greatest from 1996 to 2000. During this time the private sector's interest rate forecasts are still fairly good at predicting the future interest rate. This implies that the Reserve Bank of New Zealand changed its monetary policy but was able to communicate this successfully to the public which helped them to make fairly good forecasts of the future interest rate

despite the changing monetary policy behaviour. Hence, transparency, credibility and communication are very important for the private sector to assess the future interest rate. It seems that these factors are even more important than whether a country is pursuing inflation targeting or not.

The outcome furthermore shows that the inflation targeting strategy has successfully helped the countries to control inflation and bring it down from the high levels experienced in the 1980's. It seems that by deciding inflation targets that are communicated to the public, inflation expectations have decreased and the central banks are not forced to indulge in drastic interest rate increases which affect the economic growth negatively in order to keep inflation around its target.

5.2 Measuring the inflation and non-inflation targeting countries behaviour using the Taylor rule

The third chapter of this thesis estimates the Taylor rule. Since the empirical tests in the second chapter do not give the expected result it leaves room for further investigation of the central banks' behaviour. The Taylor rule is a widely recognised model that can be used to analyse monetary policy and it is therefore employed in this study.

By using Taylor's original and equally large weights (i.e. 0.5) on inflation and output in combination with the countries individual inflation target the "Taylor interest rate" is calculated. Taylor's interest rate is then compared with the policy interest rate actually set by the monetary policy makers in the different countries.

The results reveal that the UK and New Zealand have had policy rates that were higher than the Taylor interest rate for the longest periods of time. The actual interest rate in the UK was higher than Taylor's interest rate over almost the whole time period, but it does decrease after 2000 and is only slightly higher than Taylor's recommendation. In 2006 the actual interest rate falls below Taylor's interest rate. This indicates that the Bank of England might have been stimulating the economy by lowering the interest rate. Similar patterns are found in all of the inflation targeting countries. The interest rates either fall below Taylor's recommendation as in Sweden and Canada or they converge and lie very close to each other as seen in Australia.

Most of the inflation targeting countries have employed an interest rate that was higher than Taylor's recommendation at the start of the inflation targeting era. But as time passes by and we enter the new millennium, the central banks tend to decrease the interest rates. However the actual interest rate in the UK, New Zealand and Australia tend to be slightly higher than Taylor's suggested rate after

2000. This suggests that these countries have experienced inflation pressures that had to be controlled somewhat more than the Taylor rule suggests. This has not been the case in Sweden and in Canada, which might imply that the UK, New Zealand and Australia have focused more on their inflation target than Sweden and Canada.

A similar pattern of high interest rates at the start of the testing period can be seen in the non-inflation targeters, the U.S., the Eurozone and even in Japan. According to the Taylor rule, Bank of Japan should implement an interest rate that was negative between 1999 and 2002. After these years Taylor's interest rate increases and reaches 2 per cent in 2006 while the actual interest rate remains at close to zero. The policy rates set by the ECB and the Federal Reserve Bank move closely with Taylor's interest rate until 2002 and 2000 respectively. After the burst of the IT-bubble and the September 11th attacks the central banks decided to stimulate economic growth by lowering interest rates. The loose monetary policy caused the policy interest rates to stay well below Taylor's suggested interest rate until the middle of 2006 in the Eurozone and the U.S.

The first part of the third chapter concludes that policy interest rates were low compared to the interest rate calculated by using the Taylor rule in most of the inflation and non-inflation targeting countries after 2001.

The second part of the empirical analysis in chapter three estimates the Taylor rule by using the econometric procedure GMM. The Taylor equation which is utilised includes a smoothing parameter. Central banks often move the policy interest rate by either lowering or increasing the rate in small steps from the current rate, the size of the steps which are extensively used is 0.25 percentage points. If the central bank wants to, for example, increase the interest rate by more than 0.25 percentage points it normally does so by increasing the interest rate in a number of steps following each other. In this sense one can claim that the future interest rate is decided upon the current interest rate.

The results found when estimating the Taylor equation that includes a smoothing parameter show that, the smoothing parameter explains most of the variation in the policy interest rate. The two estimators that were supposed to be assessed i.e. the weights put on keeping inflation close to its target and the output gaps closed, were small and in some cases statistically insignificant. The results imply that policy makers are primarily interested in the past interest rate and not particularly interested in the inflation level and the size of the output gap when deciding on the future policy rate. Other economists have questioned the role and interpretation of the smoothing parameter and by following their lead the Taylor equation was estimated once more without the smoothing parameter.

The result found when estimating the Taylor equation that excludes the smoothing parameter shows that all of the inflation targeting countries except New Zealand, Australia and Sweden have put more weight on stimulating economic growth in order to close the output gap than on controlling that the inflation level hits its target. New Zealand is furthermore the only country that has focused significantly more on controlling inflation than on output. It seems that the Reserve Bank of New Zealand is the only central bank in this study that has run an uncompromising inflation targeting strategy.

The central banks in Australia and Sweden have focused slightly more on controlling the inflation level than on closing the output gap; however the difference in size of the estimators is not large. The central banks in the UK and Canada have on the other hand allowed their policy interest rate decisions to depend more on the output gap than on the inflation target.

The size of the estimators is different in the non-inflation targeting countries. The Federal Reserve Bank seems to focus more on controlling inflation than on stimulating economic growth when estimating the regression for the whole time period. As, expected from the graphic analysis, this changes dramatically when testing the time period 2002-2007. During these years the Federal Reserve seems to put all its efforts on promoting economic growth. This seems to be the case in the Eurozone as well. The estimator that concentrates on closing the output gap is larger than one while the estimator that controls inflation is zero. This implies that most central banks have run loose monetary policy after 2000. And at the same time the inflation levels have successfully decreased from the high levels which were observed in the 1970's and -80's.

5.3 THE ROLE OF MONETARY POLICY IN THE CURRENT FINANCIAL CRISIS

The fourth chapter investigates what caused the financial crisis. Low interest rates and ever increasing house prices did lay an excellent foundation for what was to happen. The first part of the chapter finds that house prices in the UK, New Zealand, Canada and Sweden are instantly sensitive to increasing interest rates. In the U.S. and Australia it takes up to one and a half years before interest rates start to affect the house prices. But one can confirm that increasing interest rates are able to cool off quickly rising house prices and this validates Taylor's criticism of the Federal Reserve Bank's low policy interest rate. The rapid growth in house prices could have been slowed down if the policy interest rate had been set at a higher level. However this would probably have come with a negative impact on economic growth and the example from Sweden shows that inflation targeting central banks may lose their credibility if they interfere with the house market.

Looking at the development of house prices it is clear that the increase in prices has not been most dramatic in the U.S. Prices have actually grown faster in, for example, New Zealand and the UK during the same time period. Hence the question remains; how could falling house prices in the U.S. cause a global financial crisis?

The second part of the fourth chapter investigates how the subprime market worked in order to find answers. The "great moderation" with stable macroeconomic development made the participants in the market to forget about risks and risk premiums declined. Investors searched for higher yields and bank managers and financial wizards were not late in offering financial instruments that could deliver higher yields. The banks sold their loans in securitizations to investors and were able to move them away from their own balance sheets. This created a whole market of ABS, ABS CDO, ABS CDO^2 products, which basically had its value in a mortgage that had financed the purchase of a house by a person with impaired credit history. The market boomed as banks and investors were earning money. They would continue to make profits as long as house prices continued to increase. When this development came to a halt and subprime housing prices started to decline and defaults on subprime mortgages rose, banks suddenly became concerned about other banks' exposure to the risks of securitized products. Since the products were not presented on the banks' balance sheets no one really knew how much exposure each bank faced. Suddenly the down-side risks became very apparent and the financial crisis was flourishing.

Even though low interest rates supported the growth in house prices and gave incentives to the financial wizards, it did not cause the crisis. What caused the crisis was lack of regulation and financial wizards who in their search for profit ignored the risks. Better control of the financial market activities is therefore called for because the situation that existed in the subprime market before the crisis can be described as the Wild West of the financial markets. Where bankers were allowed, by regulators, to construct whatever financial vehicles one could imagine without any consideration of the risks involved.

5.4 PROPOSALS FOR FURTHER RESEARCH

Proposal for further research is to measure the reactions in financial markets to macroeconomic data announcements compared to interest rate changes made by the central bank in a way that could be inspired by Lasaosa's (2005) study for the inflation targeting countries in this thesis. One could investigate whether it is possible to find another proxy variable for the expected future interest rate. Case studies on this subject that include personal interviews would be another approach in finding out how credible and foreseeable the monetary policy is in inflation targeting countries compared to non-inflation targeting countries.

Further research on models that deal with asset prices could be beneficial for policy makers. Many economists have searched for ways to detect asset bubbles and found that it is not possible. For example Gürkanyak (2008) finds that econometric tests do not provide robust estimates that can decide if rapid stock price increases are bubbles or based on fundamentals. Despite this further research on how to detect bubbles may be beneficial - as well as better integrated macroeconomic modelling on fluctuations in the financial markets.

Research on how to efficiently regulate the financial market is also called upon. This is a tricky business and Aizenmann (2009) argues that overregulation implemented by too ambitious politicians may cause economic stagnation.

REFERENCES

Adalid, R. and Detken, C. (2007), "Liquidity shocks and Asset Price Boom/Bust Cycles", *ECB Working paper series*, No. 732 February, Frankfurt am Main.

Adrian, T. and Song Shin, H. (2009), "The Shadow Banking System: Implications for Financial Regulation", *Federal Reserve Bank of New York, Staff Report,* No. 382, New York.

Aizenman, J. (2009), "Financial Crisis and the Paradox of Under- and Over-Regulation", *NBER Working Paper*, No. 15018.

Albagli, E. and Schmidt-Hebbel, K. (2004), *By How Much and Why do Inflation Targeters Miss Their Targets?*, Central Bank of Chile, Santiago.

Ammer, J. and Freeman, R. T. (1995), "Inflation Targeting in the 1990s: The Experiences of New Zealand, Canada and the United Kingdom", *Journal of Economics and Business*, Vol. 47(2), pp. 165-192.

Ashcraft, A.B. and Schuermann, T. (2008), "Understanding the Securitization of Subprime Mortgage Credit"*, Federal Reserve Bank of New York Staff Report,* No. 318, New York.

Assenmacher-Wesche, K. and Gerlach, S. (2009), "Financial Structure and the Impact of Monetary Policy on Property Prices", Presented at the conference: *Financial Markets and the Macroeconomy: Challenges for Central Banks*, November 6-7, 2009. Swedish Riksbank. Stockholm.

Australian Bureau of Statistics (21/8-2010), http://www.abs.gov.au/AUSSTATS/abs@.nsf/ProductsbyTopic/A50B6B8CF85F0474CA25722900179E3F?OpenDocument.

Bank of Canada (1996), Annul report 1996, February 1997, Ottawa.

Bank of Canda (2006a), *Renewal of the Inflation-Control Target: Background Information*, November 2006, Ottawa.

Bank of Canda (2006b), *Annual report 2006,* February 2007, Ottawa.

Battelino, R., Broadbent, J., and Lowe, P. (1997), "The Implementation of Monetary Policy in Australia", *Research Discussion Paper*, No. 9703, July 1997, Reserve Bank of Australia, Sidney.

Baum, C., Schaffer, M., and Stillman, S. (2003), "Instrumental Variables and GMM: Estimation and Testing", Boston College, Department of Economics, *Working Paper,* No. 545, Boston.

Bean, C. (2003), "Asset Prices, Financial Imbalances and Monetary Policy: Are Inflation Targets Enough?", *BIS Working Paper*, No. 140, Bank for International Settlements, Basle.

Bean, C. (2009), "The Great Moderation, the Great Panic and the Great Contraction", Schumpeter Lecture at the Annual Congress of the European Economic Association, August 25,Barcelona.

Becker, J., Labaton, S., Stolberg, S.G. (2008), "Bush Drives for Home Ownership Fuelled Housing Bubble", The New York Times, http://www.nytimes.com/2008/12/21/business/worldbusiness/21ihtadmin.4.18853088.html?pagewanted=2&_r=1.

Belke, A., Kösters, W., Leschke, M., and Polleit, T. (2003), "Challenges to ECB credibility", *ECB Observer*, No 5, 8 July 2003.

Belke, A., Kösters, W., Leschke, M., and Polleit, T. (2005), "Back to the Rules*", Hohenheimer Diskussionsbeiträge*, Nr. 268/2005, Stuttgart.

Belke, A. and Polleit, T. (2007), "How the ECB and the US Fed Set Interest Rates", *Applied Economics*, Vol.39 (17), pp. 2197-2209.

Belke, A., Bordon, I., Hendricks, T. and Orth, W. (2010), "Global Liquidity and Asset Prices Revisited", *Institutional Investor's Guide to Global Liquidity II*, Vol. 2010, pp. 29-39.

Belke, A. (2010), "Die Auswirkungen der Geldmenge und des Kreditvolumens auf die Immobilienpreise- Ein ARDL-Ansatz für Deutschland", *Jahrbücher für Nationalökonomie und Statistik*, Vol. 230/2, pp. 138-162.

Belke, A. and Klose, J (2010), "(How) Do the ECB and the Fed React to Financial Market Uncertainty? The Taylor Rule in Times of Crisis", *DIW Berlin Discussion Papers*, Nr. 972, Deutsches Institut für Wirtschaftsforschung, Berlin.

Berg, C., Jansson, P., and Vredin, A. (2006), "How Useful Are Simple Rules for Monetary Policy? The Swedish Experience", *Sveriges Riksbank Research Papers Series*, No. 12, Stockholm.

Bernanke, B.S. and Mishkin, F.S. (1997), "Inflation Targeting: A New Framework for Monetary Policy?", *Journal of Economic Perspectives,* Vol. 11(2), pp. 97-116.

Bernanke, B. S., Gertler, M. and Gilchrist, S. (2000), "The Financial Accelerator in a Quantitative Business Cycle Framework", In Ed. J.B. Taylor and M. Woodford: *Handbook of Macroeconomics,* , North-Holland, Elsevier BV, Amsterdam.

Bernanke, B. S., Laubach, T., Mishkin, F. S. and Posen, A. S. (2001), *Inflation Targeting: Lessons from the International Experience*, New Ed., Princeton University Press, Princeton.

Bjørnland, H. and Jacobsen, D. (2009), "The Role of House Prices in the Monetary Policy Transmission Mechanism in Small Open Economies", *Working Paper*, Financial Markets Department, Norges Bank, Oslo.

Borio, C. and Lowe, P. (2002), "Asset Prices, Financial and Monetary Stability: Exploring the Nexus", *BIS Working Papers*, No. 114, Bank for International Settlements, Basle.

Bruyere, R., Cont, R., Copinot, R., Fery, L., Jaeck, C., and Spitz, T. (2006), *Credit Derivatives and Structured Credit – A Guide for Investors*, Wiley Finance, Chichester, England.

Calza, A., Monacelli, T., and Stracca, L. (2007), "Mortgage Markets, Collateral Constraints and Monetary Policy: Do Instructional Factors Matter?" *CEPR Discussion Paper* , No. DP6231, Centre for Economic Policy Research, London.

Campbell, J. Y., Lo, A. W., and MacKinlay, A. C. (1997), *The Econometrics of Financial Markets*, Princeton University Press, Princeton.

Carlson, J. B., McIntire, J. M., and Thomson, J. B. (1995), "Federal Funds Futures as an Indicator of Future Monetary Policy: A Primer", *Federal Reserve Bank of Cleveland Economic Review*, Issue 31(1), pp. 20-30.

Carpenter, S. B. (2004), "Transparency and Monetary Policy: What Does the Academic Literature Tell Policy makers?", *FEDS Discussion Paper*, No. 2004-35, Federal Reserve Division of Monetary Affairs, Washington, DC.

Carstensten, K. and Colavecchio, R. (2004), "Did the Revision of the ECB Monetary Policy Strategy Affect the Reaction Function?" *Kiel Working Papers*, Nr. 1221, Kiel Institute for the World Economy?, Kiel.

Chance, D. M. (2003), *Analysis of Derivatives for the CFA Program*, Association for Investment Management and Research, Charlottesville.

Chortareas, G., Stasavage, D., and Sterne, G. (2002), *Does it Pay to Be Transparent? International Evidence from Central Bank Forecasts*, Federal Reserve Bank of St. Louis, St. Louis.

Chicago Board of Trade (2003), "Reference Guide: CBOT® Fed Funds Futures", Board of Trade of the City of Chicago, Chicago.

Citigroup, (2005), "Introduction to the Home Equity Loan Market", *Citigroup report,* New York.

Citigroup, (2008a), "Are the Brokers Broken?", *Citigroup report,* London.

Citigroup, (2008b), "Where Should Hedge funds Keep their Cash?, *Citigroup report,* London.

Clarida, R., Gali, J. and Gertler, M. (1998), "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review*, Vol. 42, pp. 1033-1067.

Clarida, R., Gali, J. and Gertler, M. (2000), "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory", *Quarterly Journal of Economics*, Vol. 115, pp. 147-180.

Claus, I. and Scobie, G., (2001), "Household net wealth: an international comparison", New *Zealand Treasury Working Paper*, No. 01/19, Wellington.

Crouhy, M.G., Jarrow, R.A., and Turnbull, S.M. (2008), "The Subprime Crisis of 2007", *The Journal of Derivatives*, Vol. 16, No. 1, pp. 81-110.

de Grauwe, P. (2003), "The Central Bank That Has Missed the Point", *Financial Times*, May 13, 2003.

Demertzis, M. and Hughes Hallet, A. (2002), "Central Bank Transparency in Theory and Practice", *CEPR Discussion Paper*, No: 3639, Centre for Economic Policy Research, London.

Demyanyk, Y. and Hemert, O.v. (2009), "Understanding the Subprime Mortgage Crisis", *The Review of Financial Studies,* Oxford University Press, Oxford.

Deng, Y., Gabriel, S.A., and Sanders, A.B. (2010), "CDO Market Implosion and the Pricing of Subprime Mortgage-Backed Securities" *Journal of Housing Economics.*

Detken, C. and Smets, F. (2004), "Asset Price Booms and Monetary Policy", In Siebert, H, ed. *Macroeconomic Policies in the World Economy*, Springer, Berlin.

Dornbusch, R., Fischer, S. and Startz, R. (1998), *Macroeconomics*, 7th international ed. Irwin/McGraw-Hill, New York.

Engel, R. E. and Granger, C. W. J. (1987), " Co-Integration and Error Correction: Representation, Estimation, and Testing", *Econometrica*, Vol. 55, No 2 pp. 251-276.

Engelbrecht, H-J. and Loomes, R. (2002), "The Unintended Consequences of Using the MCI as an Operational Monetary Target in New Zealand: Suggestive Evidence From? Rolling Regressions", *New Zealand Economic Papers.*

Eviews (2009), Eviews 7 User's Guide II, Quantitive Micro Software, U.S.

Fabozzi, F.J. (2000), "Fixed Income Analysis for the CFA program", FJF Associates, Pennsylvania.

Fannie Mae (2010), http://www.fanniemae.com/aboutfm/loanlimits.jhtml?p=About+Fannie+Mae&s=Loan+Limits.

Faust, J., Rogers, J.H. and Wright J.H. (2001), "An Empirical Comparison of Bundesbank and ECB Monetary Policy Rules", *FRB International Finance Discussion Papers*, No 705, Board of Governors of the Federal Reserve System, Washington, DC.

Federal Reserve Bank (1998), "Testimony of Chairman Alan Greenspan", *The Federal Reserve's midyear report on monetary policy,* Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, July 21, 1998, Washington, DC.

Federal Reserve Bank (1999), "Testimony of Chairman Alan Greenspan", *The Federal Reserve's midyear report on monetary policy,* Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, February 23, 1999, Washington, DC.

Federal Reserve Bank Statistical Release (2011), http://www.federalreserve.gov/releases/chargeoff/delallsa.htm, March 2011.

Felstein, M. (Ed.), (1999) *The Costs and Benefits of Price Stability*, University of Chicago Press, Chicago.

Financial Times, (2010), *UK house price puzzle: comparing indices*, ft.com/money-supply, October 28, 2010, http://blogs.ft.com/money-supply/2010/10/28/uk-house-price-puzzle-comparing-indices/?.

FHFA, (2008), "Statement of FHFA Director James B. Lockhart on the Conservatorship of Fannie Mae and Freddie Mac", Federal Housing Finance Agency, September, 2008, Washington, DC.

FHFA (May 2011), "Conforming Loan Limit", http://www.fhfa.gov/Default.aspx?Page=185.

Friedman, M. (1972), "Have Monetary Policies Failed?", *American Economic Review (Papers and Proceedings)*, Vol. 62, pp.11-18.

Frisell, L. and Yazdi, M., (2010) "The price development in the Swedish housing market- a fundamental analysis", Economic *Review,* No. 2010:3, Riksbanken, Stockholm.

Fung B. S. C. (2002), "A VAR analysis of the effects of monetary policy in East Asia", *BIS Working Papers,* No 119, Monetary and Economic Department, Bank for International Settlements, Basle.

Geraats, P. M. (2001), "Why Adopt Transparency? The Publication of Central Bank Forecast", *ECB Working Paper Series*, No. 41, European Central Bank, Frankfurt am Main.

Geraats, P. M. (2002), "Central Bank Transparency", *Economic Journal*, Vol. 112 November, pp. F532-F565.

Gerlach, S. and Schnabel, G. (1999), "The Taylor Rule and Interest Rates in the EMU area: A note", *BIS Working Papers*, No. 73, August 1999, Bank for International Settlements, Basle.

Giavazzi, F. and Mishkin, F. (2006), "En utvärdering av den svenska penningpolitiken 1995-2005", *Rapporter från Riksdagen 2006/2007: RFR1*, Finansutskottet, Stockholm.

Giese, J. and Tuxen, C. (2007), "Global Liquidity, Asset Prices and Monetary Policy: Evidence from Cointegrated VAR Models", *Working Paper*, University of Oxford and University of Copenhagen, Copenhagen.

Goodhart, C. and Hofmann, B. (2008), "House Prices, Money, Credit, and the Macro Economy", *Oxford Review of Economic Policy*, 2008; 24; 206-209.

Gorton, G. (2009), "The Subprime Panic", *European Financial Management*, Vol. 15(1), 10-46, Wiley Finance.

Gorton, G. (2010), "Questions and Answers about the Financial Crisis", *NBER Working Paper*, No 15787.

Gorton, G. and Metrick, A. (2010), "Haircuts", *Yale ICF Working Paper*, No 09-15, International Center for Finance Yale School of Management, New Haven.

Gorton, G. and Souleles, N.S. (2005), "Special Purpose Vehicles and Securitization", *Federal Reserve Bank of Philadelphia Working Paper*, No. 05-21.

Gosselin, M-A. (2007), "Central Bank Performance under Inflation Targeting", *Bank of Canada Working Paper 2007-18*, March 2007, Ottawa.

Greene, W.H. (2003), *Econometric Analysis*, 5th Edition, Prentice Hall, U.S.

Gros, D. (2007), "Bubbles in real estate? A Longer-Term Comparative Analysis of Housing in Europe and the US," *CEPS Working Document*, No. 276/ October, Centre for Economic Policy Research, Brussels.

Gruen, D. and Stevens, G. (2000), "Australian Macroeconomic Performance and Policies in the 1990's", *The Australian Economy in the 1990s*. Reserve Bank of Australia 2000 conference, Sidney.

Gujarati, D.N. (1995), *Basic Econometrics*, 3rd Edition, McGraw-Hill International Edition, New York.

Gürkaynak, R. S., Levin, A. T., and Swansson, E. T. (2006), "Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the U.S., U.K, and Sweden", *Federal Reserve Bank of San Francisco Working Papers*, No.2006-09, San Francisco.

Gürkaynak, R. S., Sack, B., and Swansson, E. T. (2007), "Market-Based Measures of Monetary Policy Expectations", *Journal of Business and Economic Statistics,* Vol. 25(2), pp. 201-212.

Gürkaynak, R.S. (2008), "Econometric Tests of Asset Price Bubbles: Taking Stock", *Journal of Economic Surveys,* Vol. 22, No. 1, pp. 166-186.

Hamilton, J. D. (1994), *Time Series Analysis*, Princeton University Press, Princeton.

Hendry, D. F. and Juselius, K. (2000), *Explaining Cointegration Analysis: Part II*, Department of Economics, University of Copenhagen, Copenhagen.

Herring, R. and Wachter, S. (2003), "Bubbles in Real Estate Market", *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies,* Chapter 14, Edited by Hunter, Kaufman and Pomerleano, MIT Press.

Herrmann, F. (2003), "Comparing Monetary Policy Strategies: Towards a Generalized Reaction Function", *Kiel Working Paper*, No. 1170, Kiel Institute for World Economics, Kiel.

IMF Outlook (2005), "Does Inflation Targeting in Emerging Markets?", *IMF Outlook 2005, Building Institutions*, Ch. 4, International Monetary Fund, Washington, DC.

Iossifov, P., Čihák, M., and Shanghavi, A. (2008), "Interest Rate Elasticity of Residential Housing Prices, *IMF Working Paper*, No. 08/247, International Monetary Fund, Washington, DC.

Ito, K. (2008), "Oil Price and the Russian Economy: A VEC Model Approach", *International Research Journal of Finance and Economics*, No. 17.

Johansen, S. (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models", *Econometrica*, Vol. 59, pp. 1551-1580.

Johansen, S. (1995), *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press, Oxford.

JP Morgan, (2009), "Thinking About Non-Agency RMBS Credit", *JP Morgan Report,* New York.

Judd, P. J. and Rudebusch, G.D. (1998), "Taylor's Rule and the Fed: 1970-1997", *Federal Reserve Bank of San Francisco Economic Review 1998*, WP/07/188, San Francisco.

Kiff, J. and Mills, P. (2007), "Money for Nothing and Checks for Free: Recent Developments in US Subprime Mortgage Markets", *IMF Working Paper,* WP/07/188, International Monetary Fund, Washington, DC.

Lang, J., Sack, B., and Whitesell, W., (2003*),* "Anticipations of Monetary Policy in Financial Markets", *Journal of Money, Credit, and Banking,* Vol. 35 (3), pp. 889-909.

Lasaosa, A. (2005), "Learning the rules of the new game? Comparing the reactions in financial markets to announcements before and after the Bank of England's operational independence", *Bank of England Working Paper*, No. 244, London.

Macklem, T. (2002), "Information and Analysis for Monetary Policy, Coming to a Decision", *Bank of Canada Review*, summer 2002, Ottawa.

Mankiw, N. G. (2001), *U.S. Monetary Policy During the 1990s*, Prepared for a conference on "Economic Policy During the 1990s", Kennedy School of Government, June 2001, *NBER Working Paper*, No. w8471.

Mishkin, F. S. (1997), "The Causes and Propagation of Financial Instability: Lessons for Policymakers", *Maintaining Financial Stability in a Global Economy*, Symposium Proceedings Federal Reserve Bank of Kansas City, pp. 55-96, Kansas City.

Mishkin, F. S. (1999), "International Experiences with Different Monetary Policy Regimes", *Journal of Monetary Economics*, Vol. 43, No. 3, pp. 579-605.

Mishkin, F. S. (2007a) "Housing and Monetary Transmission Mechanism", *NBER Working Paper*, No. 13518.

Mishkin, F. S. (2007b), *Monetary Policy Strategy,* MIT Press, Cambridge, Massachusetts.

Morgan Stanley, (2006), "Credit Derivatives", *Morgan Stanley Report,* New York.

OECD (2000) "House price and economic activity", *OECD Economic Outlook*, No 68, pp. 169-184, Organisation for Economic Co-operation and Development.

Orphanides, A. (2006) "The Road to Price Stability," *Finance and Economics Discussion Series*, No. 2006-05, Federal Reserve Board, Washington, DC.

Österholm, P. (2005) "The Taylor Rule: A Spurious Regression?", *Bulletin of Economic Research,* Vol. 57 (3), pp. 217-247.

Poole, W., Rasche, R. H., and Thornton, D. L. (2002) *Market Anticipations of Monetary Policy Actions*, Federal Reserve Bank of St. Louis, St. Louis.

RBC, (2010), "Credit Strategy, Damned If They Do, Damned If They Don't", *RBC Report,* London.

Reserve Bank of New Zealand (2004), *Central Banking in New Zealand*, www.rbnz.govt.nz/about/central_bankingnz.pdf, Wellington.

Reserve Bank of New Zealand (2007), *Explaining New Zealand's Monetary Policy*, www.rbnz.govt.nz/publications/3064172.pdf. Wellington.

Riksbank (2006), *Inflation Report 2006:1,* Stockholm.

Riksbank (2009), "Global Recession and Financial Stability", *Financial Stability Report*, No. 1, 2009, Stockholm.

Roger, S. and Stone, M. (2005), "On target? The International Experience with Achieving Inflation Targets", *IMF Working Paper,* No. 05/163, International Monetary Fund, Washington, DC.

Romer, D. (2001), *Advanced Macroeconomics,* Second edition, McGraw-Hill, New York.

Rossi, C.V. (2010), "Anatomy of Risk Management Practices in the Mortgage Industry: Lessons for the Future", *Research Institute for Housing America Research Paper*, Mortgage Bankers Association, Washington, DC.

Rudebusch, G. D. (2002), "Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia", *Journal of Monetary Economics*, Vol. 49, pp. 1161-1187.

Sardoni, C. and Randall Wray, L. (2006), "Monetary Policy Strategies of the European Central Bank and the Federal Reserve Bank of the United States", *Journal of Post Keynesian Economics*, Vol. 28 (3), pp. 451-472.

Schmidt-Hebbel, K. and Tapia, M. (2002), "Monetary Policy Implementation and Results in Twenty Inflation-Targeting Countries," *Central Bank of Chile Working Papers*, No. 166, June 2002, Santiago.

Söderlind, P., Söderström, U. and Vredin A. (2005), "Dynamic Taylor Rules and the Predictability of Interest Rates", *Macroeconomic Dynamics*, Vol. 9, pp.412-428, Cambridge University Press.

Söderström, U. (2001), "Predicting Monetary Policy Using Federal Funds Futures Prices", *Journal of Future Markets*, Vol. 21 (4), pp. 377-391.

Statistics Sweden (March 2010), http://www.ssd.scb.se/databaser/makro/SaveShow.asp.

Stevens, G. (1999), "Six Years of Inflation Targeting", *Reserve Bank of Australia Bulletin*, May 1999, Sidney.

Stevens, G. (2003), "Inflation Targeting: A Decade of Australian Experience", *Speech Addressed to the South Australian Centre for Economic Studies*, April 2003, Economic Briefing, Adelaide.

Svensson, L.E.O. (1997), "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets", *European Economic Review*, Vol. 41, pp. 1111-1146.

Svensson, L.E.O. (1999), "Inflation Targeting: Some Extensions", *Scandinavian Journal of Economics*, Vol. 101 (3), pp. 337-361.

Svensson, L.E.O. (2001), "Independent Review of the Operation of Monetary Policy in New Zealand: Report to the Minister of Finance", Institute for International Economic Studies, Stockholm University, Stockholm.

Svensson, L.E.O. (2003), "In the Right Direction, But Not Enough: The Modification of the Monetary-Policy Strategy of the ECB", Princeton University, Princeton.

Svensson (2010a), "Inflation Targeting after the Financial Crisis", Speech held at the research conference: *Challenges to Central Banking in the context of Financial Crisis*, February 2010, Mumbai.

Sveriges Riksbank (2001), *Annual report 2001* ,Stockholm.

Swanson, E.T. (2004), "Federal Reserve Transparency and Financial Market Forecasts of Short Term Interest Rates", *Finance and Economics Discussion Series* 2004-06, Board of Governors of the Federal Reserve System, USA.

Swanson, E.T. (2005), "Have Increases in Federal Reserve Transparency Improved Private Sector Interest Rate Forecasts?" *Journal of Money, Credit, and Banking.*

Takatoshi, I. (2004), "Inflation Targeting and Japan: Why has the Bank of Japan not Adopted Inflation Targeting?", In Kent, C. and Guttman, S., *The Future of Inflation Targeting*, Reserve Bank of Australia, Sidney.

Taylor J. B. (1993), "Discretion versus Policy Rules in Practice", *Carnegie-Rochester Conference Series on Public Policy*, Vol. 39, pp. 195-214, Stanford.

Taylor, J.B. (1998), "An Historical Analysis of Monetary Policy Rules", *NBER Working Paper,* No. 6768.

Taylor, J.B. (2007), "Housing and monetary policy", *NBER Working Paper*, No. 13682.

Taylor, J.B. (2009), "The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong, *NBER Working Paper*, No. 14631.

Taylor, J.B. and Williams, J.C. (2009), "A Black Swan in the Money Market", *American Economic Journal*: Macroeconomics 2009, 1:1, pp. 58-83.

Tsatsaronis, K. and Zhu, H. (2004), "*What Drives Housing Price Dynamics? Cross Country Evidence*", BIS Quarterly Review, March, pp. 64-78, Bank for International Settlements, Basle.

Tucker, P. (2008), "Money and credit, twelve month on", Speech at the Money, Macro and Finance Research Group 40th Annual Conference, 12 September 2008, Birkbeck College, London.

UBS, (2007), "CDO Insight", December 13, 2007, New York.

Walton, D. And Daly, K. (2003), " The ECB's Monetary Strategy Reviews: Aligning Words With Actions", *Goldman Sachs Global Economics Paper,* No. 92.

Wickman-Parak, B. (2009), "The Property Market and the Financial Crisis", Speech presented to the Swedish property federation in Stockholm, June 17th (Deputy Governor at the Riksbank), Stockholm.

Wicksell, K. (1898), *Geldzins und Güterpreise*, Capital Buch, Bibliothek der Wirtschaftsklassiker, 2005, Finanzbuch Verlag, München.

Woodford, M. (2001), "The Taylor Rule and Optimal Monetary Policy", *American Economic Review*, Vol. 91 (2), pp. 232-237.

Wooldridge, J. M. (2002), *Econometric Analysis of Cross Section and Panel Data*, The MIT Press, Cambridge, Massachusetts.

Zeileis, A., Kleiber, C., Krämer, W. And Hornik, K. (2003), "Testing and Dating of Structural Changes in Practice", *Computational Statistics and Data Analysis*, Vol. 44, pp. 109-123.

Table 1 Facts and figures on inflation targeting countries

Country	Year of Adoption	Current target	Communication	Responsibility
Australia	1993	2-3% CPI Annual	Inflation report , Quarterly, 1st issue August 1996	The CB as a whole is responsible for the Inflation Report (IR)
Brazil	1999	4.5% +/- 2.5%	Inflation report, Quarterly, 1st issue June 1999	The technical staff is responsible for the IR
Canada	1991	1-3% CPI Annual	Inflation report, Semi-annually until 2000, since then Quarterly, 1st issue May 1995	The CB governor is required to publicly explain why deviations from the target occurred. The CB Board of Governors are responsible for the IR
Chile	1999	2-4% CPI Annual	Inflation report, Every 4th months, 1st issue May 2000	The CB governor is required to publicly explain why deviations from the target occurred. The CB Board of Governors are responsible for the IR
Colombia	2000	5% +/-0.5%	Inflation report, Quarterly, 1st issue January 1999	The technical staff is responsible for the IR
Czech Rep.	1997	3% +/-1%	Inflation report, Quarterly, 1st issue April 1998	The CB as a whole is responsible for the IR
Hungary	2001	3.5% +/-1%	Inflation report, Quarterly, 1st issue 1998	The board and staff are jointly responsible for the IR
Iceland	2001	2.5%	Inflation report, Quarterly, 1st issue November 1999	The CB as a whole is responsible for the IR
Israel	1991	1-3%	Inflation report, Semi-annually, 1st issue March 1998	The CB governor is required to publicly explain why deviations from the target occurred. The board and staff are jointly responsible for the IR
Korea	1998	2.5-3.5%	Inflation report, Semi-annually, 1st issue October 1998	The CB board for governors are responsible for the IR

Country	Year of Adoption	Current target	Communication	Responsibility
Mexico	2002	3% +/-1%	Inflation report, Quarterly, 1st issue April 2000	The CB as a whole is responsible for the IR
New Zealand	1989	1-3% CPI Annual	Inflation report, Quarterly, 1st issue June 1992 Recently reduced the level of detail reported in its Monetary Policy Statement (MPC)	The Reserve Bank assigns the central bank the statutory responsibility to formulate and implement monetary policy directed to the economic objective of achieving and maintaining stability in the general level. The CB governor is required to explain why deviations from the target occurred of prices, with no mentioning of competing goals. The CB governor is responsible for the IR
Norway	2001	2.5% CPI Annual	Inflation report, Every 4 months, 1st issue 4th quarter 1994	The CB governor is responsible for the IR
Peru	2002	2.5% +/-1%	Inflation report, Every 4 months, 1st issue January 2000	The CB as a whole is responsible for the IR
Philippines	2002	4-5% in 2006	Inflation report, Quarterly, 1st issue 4th quarter 2001	
Poland	1999	2.5% +/-1%	Inflation report, Quarterly, 1st issue 1995	The monetary policy council is responsible for the IR
South Africa	2000	3-6%	Inflation report, Semi-annually, 1st issue March 2000	The CB governor is required to publicly explain why deviations from the target occurred
Sweden	1993	2% +/-1% CPI	Inflation report, Quarterly, 1st issue October 1993	The technical staff is responsible for the IR
Switzerland	2000	<2%	Switzerland does not classify itself as a IT country	The Executive board is responsible for the IR
Thailand	2000	0-3.5%	Inflation report, Quarterly, 1st issue July 2000	The board and staff are jointly responsible for the IR
UK	1992	2% CPI	Inflation report, Quarterly, 1st issue February 1993	The monetary policy committee is responsible for the IR

Source: Schmidt-Hebbel & Tapia (2002), Svensson (2001), Bernanke & Mishkin (1997), and Roger & Stone (2005)

Table 2 Inflation Reports

Country	Influence*	Economists**	Distribution***	Policy decisions and IR****
Australia	Yes	6	Free of charge for everybody	Yes
Brazil	Yes, significantly	20	Free of charge for everybody	Yes
Canada	N.a.	1	Free of charge for everybody	Yes
Chile	Yes, but not significantly	4	Free of charge for selected persons	Yes
Colombia	Yes, but not significantly	4	Free of charge for everybody	Yes
Czech Rep.	Yes, significantly	20	Free of charge for everybody	Not necessarily
Hungary	Yes, significantly	6	Free of charge for everybody	Yes
Iceland	Yes, but not significantly	1	Charge	N.a.
Israel	N.a.	N.a.	N.a.	No
Korea	Yes, significantly	7	Free of charge for everybody	Not necessarily
Mexico	Yes, but not significantly	5	Free of charge for selected persons	Yes
New Zealand	Yes, but not significantly	5	Free of charge for everybody	Yes
Norway	Yes, significantly	7	Free of charge for selected persons	Not necessarily
Peru	Yes, significantly	8	Free of charge for selected persons	Yes
Poland	N.a.	11	Free of charge for selected persons	Not necessarily
South Africa	Will be known later	2	Charge	Not necessarily
Sweden	Yes, but not significantly	20	Free of charge for everybody	Yes
Switzerland	N.a.	3	Free of charge for selected persons	Not necessarily
Thailand	N.a.	6	Free of charge for selected persons	Yes
UK	Depends	4	Free of charge for selected persons	Yes

*) Answer to question 23d: "Are private expectations/projections significantly influenced by the central bank projections published in the inflation report?"

**) Answer to question 22: "How many economists work (on a full-year basis) on the report?

***) Answer to question 20d: "Is the report distributed free of charge?

****) Answer to question 14c: "Are policy decisions necessarily derived from the IR?"

Table 2 Inflation Reports continued

Country	Impact on market analysts[1]	Freq. of MP meetings[2]	Public. of MP decisions[3]	Public. of MP minutes[4]
Australia	High	Monthly	The next day if policy change	No
Brazil	High	Monthly	Immediately after	8 days after
Canada	High	Monthly	Immediately after	N.a.
Chile	High	Monthly	Immediately after	12 weeks after
Colombia	Moderate	Monthly	Immediately after	No
Czech Rep.	Moderate	Monthly	Immediately after	11 days after
Hungary	High	Monthly	4pm on the same day	No
Iceland	High	N.a.	N.a,	N.a.
Israel	Moderate	Monthly	Immediately after	No
Korea	Moderate	Monthly	Immediately after	3 months after
Mexico	High	Daily	Yes	No
New Zealand	High	Weekly/ 8 times/year	Yes	No
Norway	High	Every 6 weeks	1.5h after	No
Peru	Moderate	Monthly	Immediately after	No
Poland	High	Monthly	2h after	6 weeks after
South Africa	Will be known later	4 times/year	2h after	Yes
Sweden	High	8 times/year	The next day	2 weeks after
Switzerland	Moderate	Quarterly	Immediately after	No
Thailand	N.a.	Every 6 weeks	3h after	No
UK	High	Monthly	Immediately after	2 weeks after

N.a. = not available

Source: Schmidt-Hebbel & Tapia, 2002, results from inquiries to 20 IT central banks conducted in mid-2002.

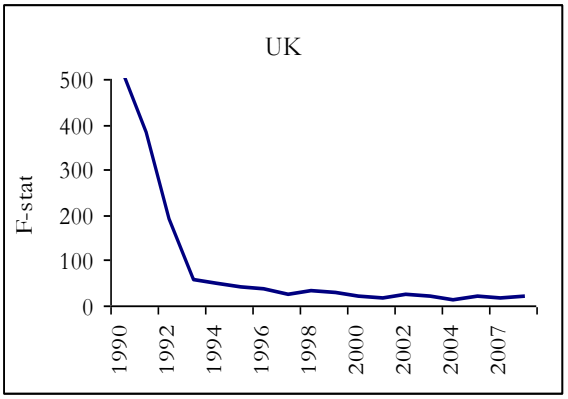
1) Answer to question 23b: "What impact has the inflation report had on the private sector: market analysts?"

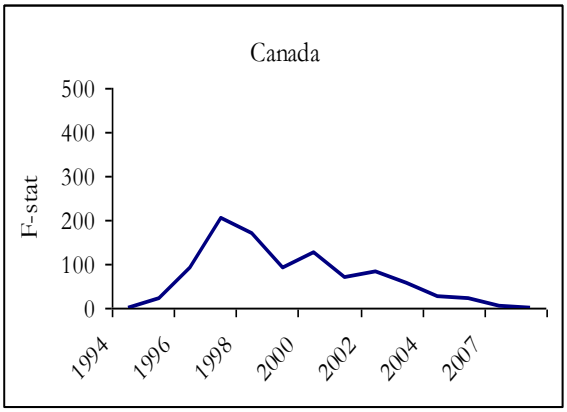
2) Answer to question 13b: "How often does the Board of Governors or Monetary Policy Board/Committee hold monetary policy meetings?" (MP meetings when policy decisions are taken)

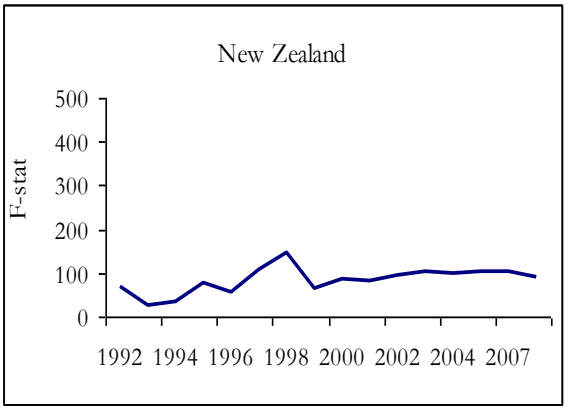
3) Answer to question 13f: "Is there a public announcement of the result of the meeting? How long after?"

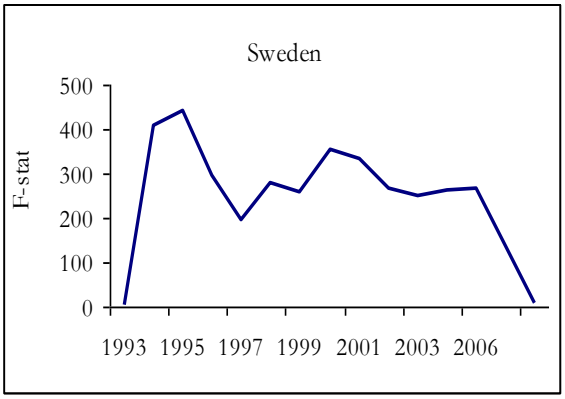
4) Answer to question 13g: "Are the records of meetings released to the press? When?"

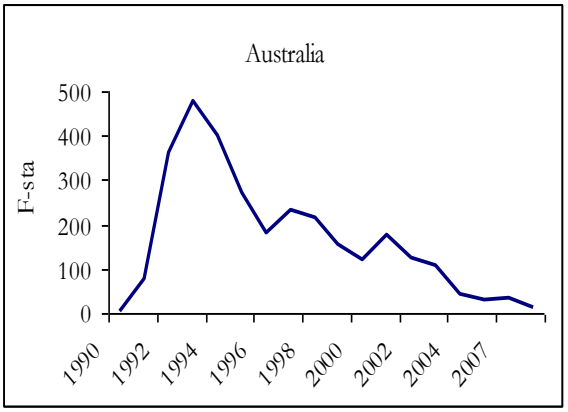
APPENDIX 2 CHOW BREAKPOINT TEST

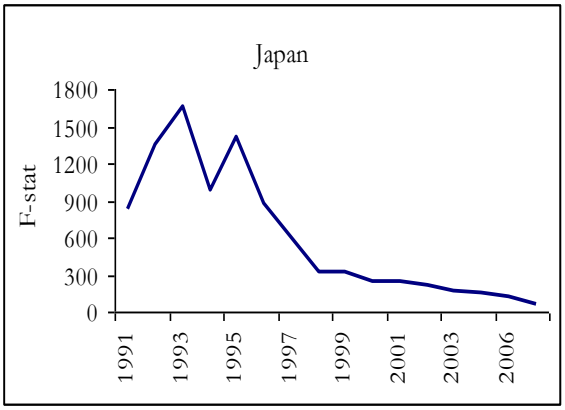


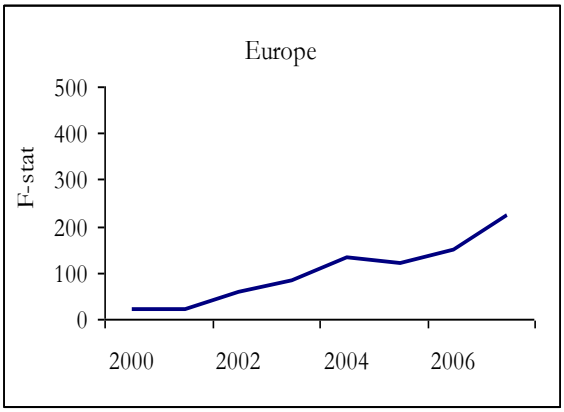


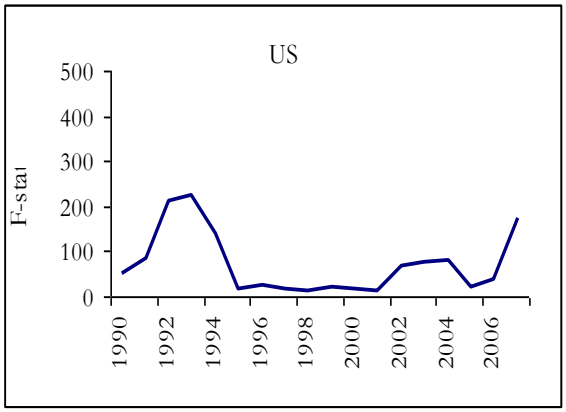






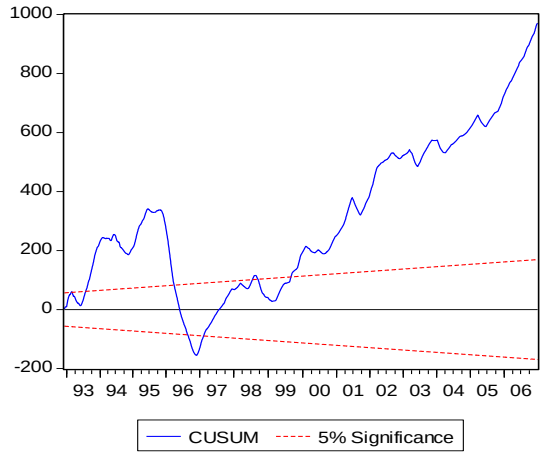



Europe
F-stat
500
400
300
200
100
0
2000
2002
2004
2006

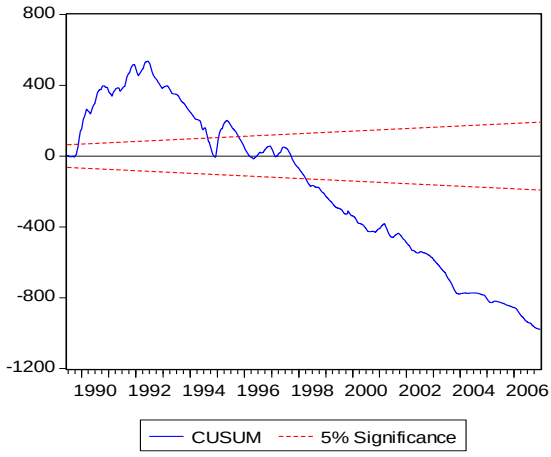

US
F-stat
500
400
300
200
100
0
1990
1992
1994
1996
1998
2000
2002
2004
2006

APPENDIX 3 CUSUM BREAK POINT TEST

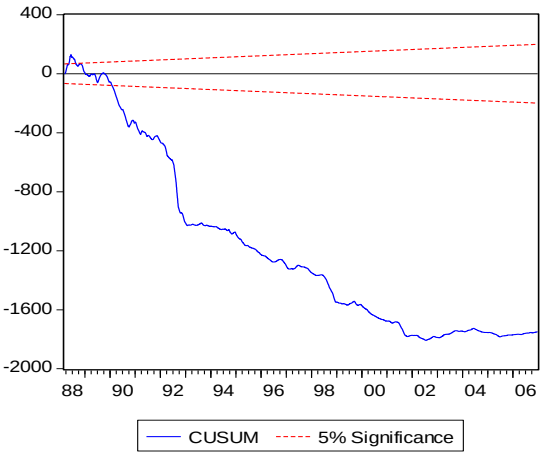
Sweden



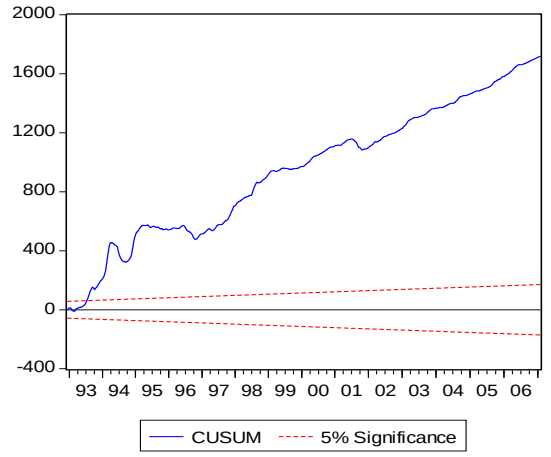
Australia



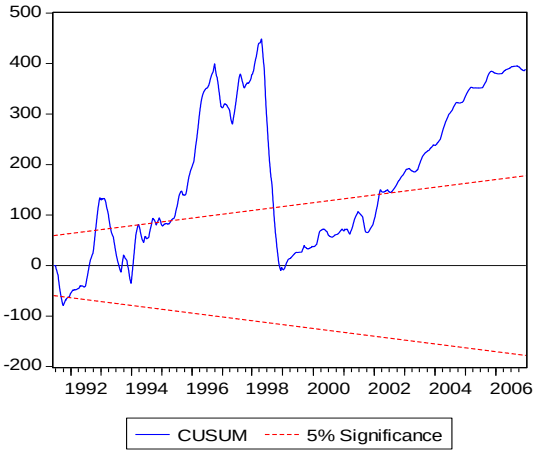
UK



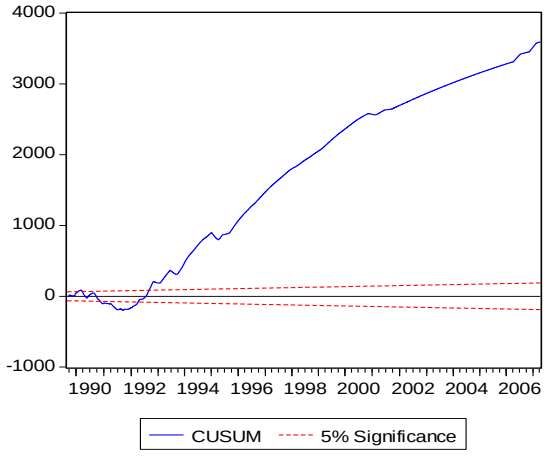
Canada



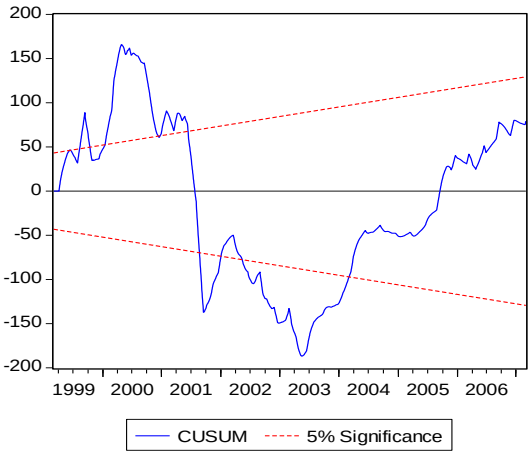
New Zealand



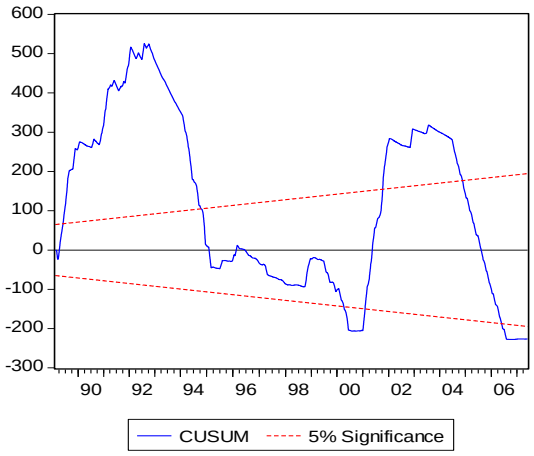
Japan



Eurozone


200
150
100
50
0
-50
-100
-150
-200
1999
2000
2001
2002
2003
2004
2005
2006
CUSUM
5% Significance

US


600
500
400
300
200
100
0
-100
-200
-300
90
92
94
96
98
00
02
04
06
CUSUM
5% Significance

UK (1989 Q4- 2010 Q1)	**loghp**	**logdi**	**logcpi**	**logcred**	**logM4**	**Logi**
Unit root (ADF)	yes (0.91)	*no (0.03)*	yes (0.96)	yes (0.97)	*weak (0.32)*	*weak (0.40)*
Lag length	3	1	4	0	0	1
Trend/ intercept	T/i	T/i	T/i	none	T/i	T/i

Australia (1987 Q2- 2009 Q4)	**loghp**	**logdi**	**logcpi**	**logcred**	**logM3**	**Logi**
Unit root (ADF)	yes (0.58)	*weak (0.56)*	yes (0.63)	yes (0.74)	yes (0.97)	*no (0.13)*
Lag length	3	0	0	6	1	1
Trend/ intercept	T/i	T/i	none	T/i	T/i	i

Sweden (1993 Q1-2010 Q1)	**loghp**	**logdi**	**logcpi**	**logcred**	**logM3**	**Logi**
Unit root (ADF)	yes (0.99)	yes (0.93)	*weak (0.40)*	yes (0.99)	yes (0.99)	*weak (0.57)*
Lag length	1	7	1	1	2	1
Trend/ intercept	T/i	T/i	none	T/i	none	None

New Zealand (1989 Q1- 2009 Q4)	**loghp**	**logdi**	**logcpi**	**logcred**	**logM3**	**Logi**
Unit root (ADF)	yes (0.94)	yes (0.95)	*no (0.03)*	yes (0.98)	yes (0.66)	*weak (0.18)*
Lag length	1	0	0	0	0	1
Trend/ intercept	T/i	T/i	none	none	T/i	T/i

Canada (1981 Q1- 2009 Q4)	**loghp**	**logdi**	**logcpi**	**logmor**	**logM3**	**Logi**
Unit root (ADF)	yes (0.95)	yes (0.99)	*no (0.0)*	*weak (0.53)*	yes (0.96)	yes (0.84)
Lag length	1	0	0	5	3	3
Trend/ intercept	T/i	T/i	T/i	i	T/i	T/i

US (1987 Q4- 2009 Q4)	**loghp**	**logdi**	**logcpi**	**logcred**	**logM2**	**Logi**
Unit root (ADF)	*weak (0.60)*	yes (0.96)	*no (0.06)*	yes (0.85)	yes (0.96)	yes (0.95)
Lag length	3	1	0	0	1	3
Trend/ intercept	T/i	None	T/i	none	none	T/i

APPENDIX 5 JOHANSEN'S COINTEGRATION TEST (UNRESTRICTED MODEL)

UK

Endogenous variables: house price (loghp), disposable income (logdi), inflation (logcpi), private credit (logcred), aggregate money supply (logM4), and interest rate (logi)
Time period: 1989 Q4 to 2010 Q1

No. of cointegrated vectors	Trace statistics	Critical value
r= 0	169.5	117.8
r≤ 1	118.0	88.8
r≤ 2	76.3	63.8
r≤ 3	47.3	42.9

Australia

Endogenous variables: house price (loghp), disposable income (logdi), inflation (logcpi), private credit (logcred), aggregate money supply (logM3), and interest rate (logi)
Time period: 1987 Q2 to 2009 Q4

No. of cointegrated vectors	Trace statistics	Critical value
r= 0	139.3	117.7
r≤ 1	89.5	88.8

Sweden

Endogenous variables: house price (loghp_sa), disposable income (logdi_sa), inflation (logcpi), private credit (logcred), aggregate money supply (logM3), and interest rate (logi)
Time period: 1993 Q1 to 2010 Q1

No. of cointegrated vectors	Trace statistics	Critical value
r= 0	181.2	117.7
r≤ 1	97.4	88.8

sa means that the time series have been seasonally adjusted by using X12-ARIMA procedure

New Zealand

Endogenous variables: house price (loghp), disposable income (logdi), inflation (logcpi), private credit (logcred), aggregate money supply (logM3), and interest rate (logi)
Time period: 1989 Q1 to 2009 Q4

No. of cointegrated vectors	Trace statistics	Critical value
r= 0	156.09	117.71
r≤ 1	101.49	88.80
r≤ 2	62.61	63.88

Canada

Endogenous variables: house price (loghp), disposable income (logdi), inflation (logcpi), mortgage (logmor), aggregate money supply (logM3), and interest rate (logi)
Time period: 1981 Q1 to 2009 Q4

No. of cointegrated vectors	Trace statistics	Critical value
r= 0	153.15	117.71
r≤ 1	107.06	88.80
r≤ 2	70.39	63.88

US

Endogenous variables: house price (loghp), disposable income (logdi), inflation (logcpi), private credit (logcred), aggregate money supply (logM2), and interest rate (logi)
Time period: 1987 Q4 to 2009 Q4

No. of cointegrated vectors	Trace statistics	Critical value
r= 0	113.39	95.75
r≤ 1	72.90	69.82